

Five-Year Review Report

Fourth Five-Year Review Report
for the
Tar Creek Superfund Site
Ottawa County, Oklahoma



PREPARED BY:

Region 6
United States Environmental Protection Agency
Dallas, Texas

September 2010

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FOURTH FIVE-YEAR REVIEW

Tar Creek Superfund Site
EPA ID# OKD980629844
Ottawa County, Oklahoma

This memorandum documents the United States Environmental Protection Agency's (EPA's) performance, determinations, and approval of the Tar Creek Superfund Site (site) fourth five-year review under Section 121(c) of the Comprehensive Environmental Response, Compensation & Liability Act (CERCLA), 42 United States Code (USC) §9621(c), as provided in the attached fourth five-year review report.

Summary of Five-Year Review Findings

The fourth five-year review indicates that the remedial actions set forth in the decision documents for this site continue to be implemented as planned. The following paragraphs provide an overview of the current status for each of the operable units (OUs) as determined by the fourth five-year review, followed by a listing of identified issues and associated recommendations.

For Operable Unit (OU) 1 (surface water/ground water), continuation of the Roubidoux Ground Water Monitoring Program has been implemented by the Oklahoma Department of Environmental Quality (ODEQ) to determine the effectiveness of the well plugging program and to monitor and assess trends in water quality of the Roubidoux aquifer as required by the OU1 Record of Decision (ROD). Since completion of the Remedial Action (RA) for OU1, additional abandoned Roubidoux wells have been plugged by the ODEQ, and both the ODEQ and EPA continue to evaluate the need to plug other abandoned Roubidoux wells, as they are identified and located, also required by the OU1 ROD. As noted in previous five-year reviews, the volume of acid mine water discharges to Tar Creek have not decreased significantly since construction of dikes and diversion channels under the surface water remedy for OU1.

Previous five-year reviews found that the fund balancing applicable or relevant and appropriate requirements (ARARs) waiver related to environmental risks related to surface water, as determined by the OU1 ROD, continued to be appropriate for the site. The third five-year review determined that the conditions regarding the waiver had not substantially changed, and that although the environmental components of the Oklahoma Water Quality Standards (OWQS) were not being met for Tar Creek, there was no indication that a threat to human health existed. The third five-year review also acknowledged that hydrologic modeling and a passive treatment pilot study (through constructed wetlands) was ongoing, but until the results were available, a determination regarding the feasibility of using such treatment technologies to address the environmental risks associated with surface water could not be made.

In support of the waiver, the OU1 ROD, signed on June 6, 1984 specifically stated that:

- Fish fillet samples from the mouth of Tar Creek, the Neosho River, the Spring River, and Grand Lake are safe for human consumption.
- The sediments provide a long-term sink for metals that effectively removes the metals from most biological processes.

Since the third five-year review, additional studies have been conducted. These additional studies gathered additional data on the surface water and sediment in site streams, including Tar Creek. These studies also gathered data from fish tissue. As a result of the fish tissue data collected, the ODEQ has issued a revised fish consumption advisory for the Tar Creek area, including the Spring and Neosho Rivers and Grand Lake. The advisory provides consumption guidelines separately for residents in the area of the Tar Creek Superfund Site and for non-residents. The ODEQ states in the advisory that the advisory does not mean fish caught in these areas are unsafe to eat, but the advisory is intended as a guideline to

allow residents to make informed choices regarding health and diet. The advisory is in effect an Institutional Control (IC) put in place by the ODEQ to provide public notice that the consumption of fish from the site potentially poses some risk to human health.

In addition, an Advanced Screening Level Ecological Risk Assessment (SLERA) has been performed for the Tri-State Mining District (TSMD) as a whole, which includes the Tar Creek Superfund Site. The draft final report indicates that contaminants of potential concern (COPCs) present in surface water, sediments, pore water, and soils within riparian and aquatic habitats posed a potential risk to ecological receptors at the site. The Detailed Ecological Risk Assessment indicated that exposure to metals in sediments poses moderate to high risks to benthic invertebrates at approximately 45% of the locations sampled during the study, including portions of Tar Creek and Lytle Creek.

In 1985, the Oklahoma Water Resources Board (OWRB) lowered the designated beneficial uses for Tar Creek due to irreversible man-made impacts associated with the past mining activities. These designated beneficial uses, still in effect, are habitat limited fishery and secondary recreation water body. The secondary recreation water body designation allows for uses where ingestion of water is not anticipated (e.g., boating, fishing, or wading). Based on data collected since the third five-year review, however, the OWQS associated with these designated uses are not being met in Tar Creek. In particular, the pH standard and the numerical criteria for toxic substances (e.g., heavy metals) which apply to all fishery classifications, including habitat-limited fisheries, are not being met. Investigations of the surface water and sediment performed under OU5 in local streams found that surface water in Tar Creek exceeded the chronic threshold values for fish and wildlife propagation of the OWQS for cadmium, lead, and zinc. Zinc concentrations in surface water exceeded the acute threshold values for fish and wildlife propagation.

Finally, the passive treatment pilot study (through constructed wetlands) being conducted under the Oklahoma Plan for Tar Creek by Oklahoma University is still ongoing. This system was constructed to treat the mine water discharges located southeast of Commerce. As noted above, the third five-year review found that until the results of this study were available, a determination regarding the feasibility of using passive treatment technology to address the environmental risks associated with surface water could not be made. Initial construction costs do not appear to be prohibitive, although long-term operations and maintenance costs are not yet available for this system. When the results of this effort are available, an evaluation and determination on the feasibility of passive treatment technology to address the risks associated with surface water will be made. An engineered remedy for OU1 may be cost effective at addressing environmental risks posed by surface water at the site.

In summary, some of the exposure assumptions and the potential risks posed to human health and the environment for surface water and sediments at the site, as stated in the OU1 ROD and summarized above, are no longer valid. Recent fish tissue data collected by ODEQ demonstrate that potential risks to human health exist through consumption of fish caught from Tar Creek, the Spring and Neosho Rivers, and Grand Lake. Metals contained within site sediments are biologically available and pose risks to ecological receptors. The concentrations of site-related contaminants in Tar Creek surface water continue to exceed the OWQS. The narrative and numerical criteria in the OWQS are designed to maintain and protect the beneficial surface water use classification of "Fish and Wildlife Propagation". Under the OWQS there are numerical "Toxic Substance" concentration limits for surface water with both "acute" and "chronic" standards listed. Under 785 OAC 45 OWQS, "acute toxicity" means the surface water concentration of a toxic substance is such that it means greater than or equal to 50% lethality to appropriate test organisms in a test sample. Under those same standards, "chronic toxicity" means the surface water concentration of a toxic substance is such that there is a statistically significant difference (at the 95% confidence level) between longer-term survival and/or reproduction or growth of the appropriate test organisms in a test sample and a control. Teratogenicity and mutagenicity are considered to be effects of chronic toxicity. In Tar Creek, Lytle Creek, and Elm Creek at the Tar Creek Site, EPA

found that cadmium, lead, and zinc concentrations in surface water samples exceed the OWQS chronic toxicity standard, and zinc concentrations also exceed the acute toxicity standard. Finally, initial construction costs for the constructed passive wetland southeast of Commerce are considered reasonable and may indicate that such a system could be an economically feasible engineered remedy for surface water at the site. For these reasons, in this fourth five-year review, the fund balancing ARARs waiver included in the OU1 ROD may no longer be appropriate and should be reevaluated.

The OU2 ROD, signed on August 27, 1997 required residential yard and High Access Area (HAA) remediation has been completed in Picher, Quapaw, Cardin and North Miami. Required remediation activities are ongoing in Miami, Commerce, and other areas of Ottawa County where chat has been found. In addition, the footprints of buildings demolished as part of the Lead Impacted Communities Relocation Assistance Trust (LICRAT) buy-out under OU4 remain to be addressed under OU2.

OU3, regarding abandoned laboratory chemicals at the former Eagle-Picher Office Complex, located in Cardin, Oklahoma, was addressed through a removal response action. No further action is necessary.

The ROD for OU4 (chat piles, other mine and mill waste, and smelter waste) was signed in February 2008 (during the fourth five-year review period). OU4 addresses the undeveloped rural and urban areas of the site where mine and mill residues and smelter wastes have been placed, deposited, stored, disposed of, or otherwise come to be located as a result of mining, milling, smelting, or related operations. OU4 includes rural residential yards located in Ottawa County outside of city or town limits except for yards that were addressed under OU2. In general, OU4 does not include roadways, alleyways, sinkholes, or mine shafts. The underground mine workings are not included as part of OU4, except as possible disposal locations for mining related wastes. Currently, the Remedial Design (RD) and RA for OU4 are being developed and implemented. The remedy selected by the OU4 ROD included providing funding to the State of Oklahoma to complete a voluntary relocation within a portion of the site. The voluntary relocation is currently in progress and is anticipated to be completed in 2010. The voluntary relocation was augmented by EPA's decision to relocate the residents of Treece, Kansas. The decision to relocate the residents of Treece was documented in an April 2010 Explanation of Significant Difference (ESD) to the OU4 ROD.

OU5 consists of sediment and surface water in Elm Creek and Tar Creek starting at the confluence of Tar Creek & Lytle Creek to the Neosho River down to the point where it flows into Grand Lake. Investigations related to OU5 are ongoing, and a remedy has not yet been selected.

In summary, the operation and maintenance (O&M) and Roubidoux Ground Water Monitoring Program for OU1, the OU2 RA, and the OU4 RD and RA are ongoing at the site. Based on the fourth five-year review data review, site inspection, interviews and technology assessment, it appears the selected remedies are functioning in a manner that is consistent with the decision documents (except as noted regarding the dikes and diversion work portions of the OU1 remedy which are not significantly reducing mine water discharges to Tar Creek). To ensure continued protectiveness, six issues are identified in the following paragraphs.

The first five issues described below are carried over from the third five-year review. Of these, the first four do not currently affect the protectiveness, but they should be addressed to ensure continued protectiveness of the selected remedies. The fifth issue currently affects protectiveness in that current data indicates that potential unacceptable risks to human health and the environment are posed by surface water and sediment at the site. However, a formal evaluation of the data through the risk assessment process is necessary to assess potential human health risks that might exist. The advanced SLERA performed under OU5 has demonstrated that environmental risks are present in site sediments and surface water, but a determination of whether or not the risks are unacceptable has not been made.

The sixth issue currently affects protectiveness in that Appendix H of the OWQS, 785 Oklahoma Administrative Code (OAC) 45 does not address restrictions on the use of ground water from the Boone aquifer and shallower ground water in areas impacted above remediation goals as called for in the OU4 ROD.

The six issues are:

1. **No O&M Plan exists for the dike and diversion channel for the Admiralty Mine Site (this issue is carried over from the third five-year review).** The ODEQ's O&M Plan for the dike and diversion channel constructed at the Admiralty Mine Site as part of the OU1 remedy was written in 1987 and facts have arisen that make it outdated. The ODEQ is responsible for maintaining the dike and diversion channel at the Admiralty Mine Site, as part of ODEQ's O&M for OU1. The dike at the Admiralty site requires some maintenance to repair damage noted during the site inspection and mowing.
2. **A determination regarding the effectiveness of the well plugging program, which was intended to prevent mine water infiltration into the Roubidoux aquifer has not been completed (this issue is carried over from the third five-year review).** The Roubidoux Ground Water Monitoring Program has collected data for a period of over 20 years since the RA to plug abandoned Roubidoux wells was completed. In the past, it was believed that the Roubidoux aquifer was being impacted by the mine water; however, only certain indicator parameters were found, and subsequent data collection over twenty years has not found any more reason to believe that the mine water is degrading the Roubidoux. It should be noted that neither EPA nor ODEQ have identified any public drinking water wells at the site that fail to meet the health-based primary drinking water standards (Maximum Contaminant Levels or MCLs) established under the Safe Drinking Water Act (SDWA), and the drinking water supplied from the Roubidoux at the site is safe for all uses. Nonetheless, all available information indicates that the primary mechanism for mine water to enter the Roubidoux aquifer is infiltration through unplugged abandoned wells or infiltration through wells that have faulty well casings and/or poor seals across the Boone Formation; consequently, it is essential that plugging of abandoned wells continue.
3. **ODEQ research has found references to 19 abandoned wells that need to be assessed for plugging (this issue is carried over from the third five-year review).** The OU1 ROD recognized that additional abandoned wells completed in the Roubidoux aquifer might be identified after completion of the OU1 RA. The ROD stated that the need to plug additional wells would be evaluated as wells were identified. The existence of wells found by ODEQ's research in historic documents has not been verified. Field work will be necessary to verify the existence of these wells and to determine whether they are completed in the Roubidoux.
4. **While significant progress has been made, there is work remaining before the OU2 RA is complete (this issue is carried over from the third five-year review).** Residential yard remediation has been completed in the towns of Picher, Quapaw, North Miami, and Cardin. However, additional work is still necessary to complete the RA for OU2. Chat has been identified in driveways and alleyways in Miami and in other areas of Ottawa County outside of the mining area. The footprints of homes demolished and removed as part of the OU4 voluntary relocation, the footprints of homes demolished in Miami due to flooding issues, and the footprints of homes demolished as part of work performed in Commerce have not been assessed to determine if additional remediation is required.
5. **An assessment of the surface water and sediment data for Tar Creek should be completed to verify that a threat to human health does not exist (this issue is carried over from the third five-year review).** The third five-year review recommended that then current surface water and sediment data for Tar Creek be evaluated to verify that no threat to human health exists in Tar Creek. Since the third five-year review, additional studies have been conducted. These additional studies gathered

additional data on the surface water and sediment in site streams, including Tar Creek. These studies also gathered data from fish tissue. Based on this data, the assumptions on which the OU1 ROD fund balancing ARAR's waiver were based are no longer valid. The OU1 ROD stated that fillets of fish caught from the mouth of Tar Creek, the Spring and Neosho Rivers, and Grand Lake were safe to eat. However, recent ODEQ data have demonstrated that potential risk to human health exists through consumption of fish caught from Tar Creek, the Spring and Neosho Rivers, and Grand Lake. The OU1 ROD also stated that the sediments in Tar Creek provide a long-term sink for metals that effectively removes the metals from most biological processes. However, the advanced SLERA documented a moderate to high risk to ecological receptors from sediment and surface water contamination associated with the site. Data from ongoing OU5 investigations of surface water and sediment show that metals concentrations in surface water in site streams continue to exceed the OWQS for its lowered designated beneficial uses.

6. **ICs restricting the use of shallow ground water have not been put in place as called for in the OU4 ROD.** The OU4 ROD calls for ICs restricting the use of the Boone aquifer and also restricting the use of any ground water that is shallower than the Boone. Specifically, the ROD calls for ICs restricting the potable and domestic use of such ground water where concentrations of site-related contaminants exceed the remediation goals established in the ROD. The IC is to be implemented through the OWQS (785 OAC 45 Appendix H). Appendix H of the OWQS states that toxic metals are present and that special well construction methods are required within the OU4 boundary due to contamination in the Boone aquifer, but there are currently no limitations placed on the use of ground water from the Boone aquifer (or other shallower ground water) for potable use, including domestic supply.

Actions Needed

To address the issues identified during the fourth five-year review, the following recommendations and follow-up actions have been identified for the site. These actions are also provided in the table following to this memorandum.

1. **Develop an O&M Plan for the dike and diversion channel at the Admiralty site.** The ODEQ indicated in the third five-year review that the last O&M Plan developed for the diversion dike and channel at the Admiralty Mine Site was prepared in 1987 and new facts may have made it outdated. The O&M Plan prepared for the Admiralty Mine Site should be updated. Maintenance needs to be performed to the dike at the Admiralty site. The maintenance items identified during the fourth five-year review site inspection should be performed. ODEQ should provide to EPA a schedule that indicates when the O&M Plan will be revised and when the necessary maintenance will be completed. This follow-up action should be completed no later than September 2012.
2. **Complete the evaluation of the effectiveness of the well plugging program that is intended to prevent mine water infiltration into the Roubidoux aquifer.** It would be beneficial to future long-term decision making if, under the Roubidoux Ground Water Monitoring Program, all the analytical results available from the Roubidoux aquifer were compiled into a single database. The database could then be used to perform statistical and trend analyses on the data to assess long-term changes to the water quality of the Roubidoux. If additional data are required to complete the evaluation, then such data should be collected. Recommendations should then be developed regarding the need for continued monitoring and/or additional actions to protect the Roubidoux aquifer if necessary. The evaluation of the effectiveness of the well plugging program should be completed by September 2014 (prior to the next five-year review).
3. **Undertake field work to determine whether the 19 wells that ODEQ found in literature actually exist, and evaluate whether plugging any wells found is warranted or feasible.** Each well location the ODEQ found in literature should be investigated, located, assessed, and if necessary and

technically feasible, plugged in accordance with the OU1 ROD. As additional potential abandoned well locations are found, field work should be undertaken to locate any wells that exist. If any wells are found, ODEQ should determine whether the well is completed in the Roubidoux aquifer, and ODEQ should plug those abandoned wells completed in the Roubidoux aquifer where it is found to be technically feasible to do so. EPA will assist ODEQ to plug as many wells as can be located. This follow-up action should be completed by September 2012.

4. **Remaining actions should be taken to complete the OU2 RA.** These actions include, but may not be limited to: 1) assessment of chat in driveways and alleyways in areas of Ottawa County, including Miami, that are outside of the mining area (approximately 450 in Miami and 50 in other areas of Ottawa County); 2) assessment of the footprints of homes demolished as part of the voluntary relocation (approximately 450 properties); 3) remediation of residential properties located outside of the boundary of the OU4 voluntary buyout, where access was previously denied and where soil lead concentrations exceed the remediation goal established in the OU2 ROD (approximately 140 properties). Owners of residential properties where access was previously denied will be offered a final opportunity to have their properties re-sampled and remediated if necessary. The next five-year review should also consider whether OU2 can be deleted from the National Priorities List (NPL). This deletion of OU2 from the NPL would be a partial deletion of the site. This follow-up action should be completed by September 2015.
5. **The EPA should complete the evaluation of current surface water and sediment data for Tar Creek to verify that no unacceptable risks to human health and the environment exist in Tar Creek.** Numerous studies have been conducted since the third five-year review. These studies have collected surface water and sediment data in Tar Creek and other site streams. If necessary, the EPA should collect enough additional data to determine if potential risks are posed to human health and the environment by the surface water and sediments in streams of the Tar Creek site. The risks should be quantified through a risk assessment. If unacceptable risks are identified, then potential remedial alternatives will be evaluated to address the identified risks. Potential remedial alternatives may include engineered remedies, such as passive treatment through constructed wetlands. A determination may also be made that it is still technically impractical to address surface water and sediment through an engineered remedy and/or that no further action is required. The risk assessment portion of this follow-up action should be completed by September 2012. If necessary, an evaluation of remedial alternatives should be completed by September 2014 (prior to the next five-year review).
6. **The IC restricting potable and domestic use of shallow ground water including the Boone aquifer as specified in the OU4 ROD should be implemented.** The OU4 ROD calls for ICs restricting the use of the Boone aquifer and also restricting the use of any ground water that is shallower than the Boone. Specifically, the ROD calls for ICs restricting the potable and domestic use of such ground water where concentrations of site-related contaminants exceed the remediation goals established in the ROD. The IC is to be implemented through the OWQS (785 OAC 45 Appendix H). Appendix H of the OWQS states that toxic metals are present and that special well construction methods are required within the OU4 boundary due to contamination in the Boone aquifer, but there are currently no limitations placed on the use of ground water from the Boone aquifer (or other shallower ground water) for potable use, including domestic supply. The ODEQ has indicated that it will explore placing a restriction in Appendix H of the OWQS limiting ground water use from the mine pool and the Boone aquifer in the immediate vicinity of the mine pool for public water supply or domestic use. The ODEQ's restriction will include treatment requirements to remove any lead above the MCL of 15 micrograms per liter. EPA suggests that the State of Oklahoma review this IC. This follow-up action should be completed by September 2011.

Determinations

I have determined that the remedy for the Tar Creek Superfund Site is protective of human health and the environment in the short term, and will remain so provided the action items identified in the five-year review report are addressed as described above.

Samuel Coleman, P.E.
Director, Superfund Division
U.S. Environmental Protection Agency, Region 6

Date

CONCURRENCES

FOURTH FIVE-YEAR REVIEW

Tar Creek Superfund Site

EPA ID# OKD980629844

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List of Acronyms

AAM	After Action Monitoring
ALM	Adult Lead Model
AOC	Administrative Order on Consent
ARARs	Applicable or Relevant and Appropriate Requirements
ATSDR	United States Agency for Toxic Substances and Disease Registry
BGS	Below Ground Surface
BHHRA	Baseline Human Health Risk Assessment
BIA	United States Bureau of Indian Affairs
BMP	Best Management Practices
CAA	Clean Air Act
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COPC	Contaminant of Potential Concern
CWA	Clean Water Act
DOI	United States Department of the Interior
ERA	Ecological Risk Assessment
EPA	United States Environmental Protection Agency
ERCS	Emergency Response Cleanup Services
ESD	Explanation of Significant Differences
FR	Federal Register
HAAs	High Access Areas
IAG	Inter-Agency Agreement
IC	Institutional Control
ITEC	Inter-Tribal Environmental Council
LEAD	Local Environmental Action Demanded
LICRAT	Lead Impacted Communities Relocation Assistance Trust
LTM	Long-Term Monitoring
MCL	Maximum Contaminant Level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/m ³	milligrams per cubic meter
MK	Morrison Knudson Corporation
MOU	Memorandum of Understanding
NCEA	National Center for Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
OAC	Oklahoma Administrative Code
OCC	Oklahoma Conservation Commission
OCHD	Ottawa County Health Department
ODEQ	Oklahoma Department of Environmental Quality
O&M	Operation and Maintenance
OSDH	Oklahoma State Department of Health
OSWER	Office of Solid Waste and Emergency Response
OUs	Operable Units
OWQS	Oklahoma Water Quality Standards
OWRB	Oklahoma Water Resources Board
ppm	parts per million
PPP	Pollution Prevention Plans

PVC	Polyvinyl Chloride
PRP	Potentially Responsible Parties
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RAO	Remedial Action Objective
RAR	Remedial Action Report
RD/RA	Remedial Design/Remedial Action
RfC	Reference Concentration
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Manager
RSKERL	Robert S. Kerr Environmental Research Laboratory
RWD4	Rural Water District Number 4
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Officer
SLERA	Screening Level Ecological Risk Assessment
SMCL	Secondary Maximum Contaminant Level
START	Superfund Technical Assessment and Response Team
TBCs	“To Be Considered” standards
TDS	Total Dissolved Solids
TSMD	Tri-State Mining District
UCL	upper confidence limits
UIC	Underground Injection Control
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
µg/dl	micrograms per deciliter
USGS	United States Geological Survey
WIC	USDA’s Women, Infant, and Children Program

Executive Summary

Pursuant to Section 121(c) of the Comprehensive Environmental Response, Compensation & Liability Act (“CERCLA” or “Superfund”), 42 United States Code (USC) §9621(c), the fourth five-year review of the remedy in place at the Tar Creek Superfund Site (“site”) located in Ottawa County, Oklahoma (and later expanded to include actions in Treece, Kansas¹), was completed in June 2010. The results of the five-year review indicate that the response actions completed to date are currently protective of human health and the environment in the short term. Except as noted in this and previous five-year reviews regarding the ineffectiveness of the portion of the Operable Unit (OU) 1 remedy designed to decrease acid mine water discharges to Tar Creek, the response actions performed appear to be functioning as designed, and the site has been maintained appropriately. No deficiencies were noted that currently impact the protectiveness of the remedy, although several issues were identified that require further action to ensure the continued protectiveness of the remedy.

Due to the complex nature of contamination associated with the site, remediation has been handled through various removal response actions and Remedial Actions (RA). Five OUs have been designated at the site. The five OUs include (a) OU1 (surface water/ground water); (b) OU2 (residential properties and High Access Areas [HAAs]); (c) OU3 (Eagle-Picher Office Complex – abandoned mining chemicals); (d) OU4 (chat piles, other mine and mill waste, and smelter waste); and (e) OU5 (sediment and surface water). Records of Decision (RODs) have been signed for OUs 1, 2 and 4.

Through the RA defined by the ROD for OU1, dikes and diversion channels were constructed at three abandoned mine openings (identified as Muncie, Big John, and Admiralty) to prevent the inflow of surface water into the abandoned mine workings. In addition, abandoned wells completed in the Roubidoux aquifer have been properly plugged to prevent migration of contaminated acid mine water from the mine workings into the underlying Roubidoux aquifer. The Oklahoma Department of Environmental Quality (ODEQ) in cooperation with the United States Environmental Protection Agency (EPA) continues to evaluate the plugging of deep abandoned wells through the Roubidoux Ground Water Monitoring Program for OU1. The Roubidoux Ground Water Monitoring Program has been conducted to determine the effectiveness of the well plugging activities at preventing contamination of the Roubidoux aquifer and to evaluate trends in water quality of the Roubidoux aquifer. In addition, the dikes and diversion channels have been evaluated to determine their effectiveness at lowering the water levels

¹ EPA Region 6 issued an Explanation of Significant Differences (ESD) on April 13, 2010. The ESD stated that EPA Region 6 will offer relocation to the residents of Treece, Kansas as part of its remedy for OU4 of the Tar Creek Site.

within the mine workings and to determine their effectiveness at eliminating the acid mine water discharges to Tar Creek.

OU2 was addressed through two removal response actions and a RA. Through the removal response actions and RA, contaminated soils at more than 2,295 residential properties and HAAs have been excavated to depths up to 18 inches to a remediation goal of 500 parts per million (ppm) for lead. The excavated soil was disposed of at permanent on-site repositories. These repositories were located in dry mining waste areas which are already contaminated.

Another removal response action resulted in the appropriate disposal of 120 containers of laboratory chemicals stored at the former Eagle-Picher Office Complex (OU3). As a result of this removal response action, the EPA determined that no further action was necessary to address OU3.

The OU4 ROD was signed in February 2008. The voluntary relocation being conducted by the State of Oklahoma and funded under the OU4 ROD is ongoing. The Remedial Design (RD) for portions of the OU4 remedy began in 2009, and RA activities were begun in late 2009. In April, 2010, EPA decided to add Treece, Kansas to the site. Specifically, EPA decided to relocate the residents of Treece to help prevent exposure to the source material deposits at Tar Creek. The decision to relocate the residents of Treece was documented in an Explanation of Significant Difference (ESD) to the OU4 ROD issued in April 2010.

Investigations related to OU5 are ongoing.

Under the statutory requirements of Section 121(c) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), P. L. 99-499, and under the implementing regulatory provisions of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300.430(f)(4)(ii), performance of five-year reviews are required for sites where hazardous substances remain on-site above levels that allow for unrestricted use and unrestricted exposure. In addition, EPA policy, as stated in the current EPA five-year review guidance, provides that five-year reviews will be conducted at sites where a pre-SARA remedial action leaves hazardous substances on-site above concentration levels that allow for unrestricted use and unrestricted exposure. EPA policy also provides that five-year reviews will be conducted at pre or post-SARA sites where the RA, once completed, will not leave hazardous substances on-site above concentration levels that allow for unrestricted use and unrestricted exposure but will require more than five years to complete. Previous

five-year reviews of the site were performed as a matter of EPA policy, because the ROD for OU1 was signed prior to the enactment of SARA, and the OU2 ROD stated that five-year reviews were not required. An Explanation of Significant Difference (ESD) to the OU2 ROD was signed in August 2007 requiring a five-year review of the OU2 remedy, and subsequent five-year reviews of OU2 are therefore required by statute. An ESD to the OU4 ROD was signed in April 2010 adding the residents of Treece, Kansas to the voluntary relocation. The first five-year review of the response actions for the site was completed in April 1994, the second five-year review was completed in April 2000, and the third five-year review was completed in September 2005.

During the fourth five-year review period, Operations and Maintenance (O&M) and ground water monitoring activities continued at the site. O&M activities include inspection and maintenance of the dikes and diversion channels constructed as part of the OU1 remedy, and performance of the Roubidoux Ground Water Monitoring Program. The O&M inspections at the Admiralty site are conducted through occasional site visits and maintenance work is conducted as needed. The Roubidoux Ground Water Monitoring Program was continued by the ODEQ through a Cooperative Agreement with the EPA.

The OU2 RA was completed by EPA in the towns of Cardin, North Miami, Picher, and Quapaw during the fourth five-year review period. Some RA work was also performed by the Cities of Afton, Commerce, Fairland, and Miami. The majority of this work was performed in the City of Commerce to address 119 properties. The City of Commerce is currently addressing a few remaining properties and final reporting. Site reconnaissance efforts performed in December 2009 have identified chat in alleyways and driveways in other areas of Ottawa County outside of the mining area, including in the City of Miami.

The Remedial Investigation/Feasibility Study (RI/FS) Reports and Proposed Plan for OU4 were made available to the public in July 2007, and the OU4 ROD was signed by EPA in February 2008 (**EPA, 2008**). The voluntary relocation included as part of the remedy for OU4 is ongoing, and is being performed by the State of Oklahoma with funding provided by EPA under the OU4 ROD. The OU4 RD began in 2009, and the RA began in late 2009 for portions of the selected remedy.

For the fourth five-year review, a data review, site inspection, interviews and technology assessment have been performed. Based on the findings from these activities, it appears the remedies are functioning in a manner that is consistent with the decision documents, except as noted here. For OU1, some of the exposure assumptions and the potential risks posed to human health and the environment for surface

water and sediments at the site are no longer valid. Recent site data demonstrate that potential risks to human health exist through consumption of fish caught from Tar Creek, the Spring and Neosho Rivers, and Grand Lake. Metals contained within site sediments are biologically available and pose risks to ecological receptors. The Oklahoma Water Quality Standards (OWQS) continue to not be met for the designated uses in Tar Creek. Finally, constructed passive wetlands may be an economically feasible engineered remedy for surface water at the site. For these reasons, the fund balancing applicable or relevant and appropriate requirements (ARARs) waiver contained in the OU1 ROD may no longer be appropriate and should be reevaluated. Also, the dikes and diversion work portions of the OU1 remedy are not significantly reducing the acid mine water discharges to Tar Creek. To ensure continued protectiveness, six issues are identified as described in the following paragraphs.

The first five issues described below are carried over from the third five-year review. Of these, the first four do not currently affect protectiveness, but they should be addressed to ensure continued protectiveness of the selected remedies. The last two issues currently affect protectiveness as described below.

The six issues are:

- 1. No O&M Plan exists for the dike and diversion channel for the Admiralty Mine Site (this issue is carried over from the third five-year review).** The ODEQ's O&M Plan for the dike and diversion channel constructed at the Admiralty Mine Site as part of the OU1 remedy was written in 1987 and facts have arisen that make it outdated. The ODEQ is responsible for maintaining the dike and diversion channel at the Admiralty Mine Site, as part of ODEQ's O&M for OU1. The dike at the Admiralty site requires some maintenance to repair damage noted during the site inspection and mowing.
- 2. A determination regarding the effectiveness of the well plugging program, which was intended to prevent mine water infiltration into the Roubidoux aquifer has not been completed (this issue is carried over from the third five-year review).** The Roubidoux Ground Water Monitoring Program has collected data for a period of over 20 years since the RA to plug abandoned Roubidoux wells was completed. In the past, it was believed that the Roubidoux aquifer was being impacted by the mine water; however, only certain indicator parameters were found, and subsequent data collection over twenty years has not found any more reason to believe that the mine water is degrading the Roubidoux. It should be noted that neither EPA nor ODEQ have identified any public drinking water wells at the site that fail to meet the health-based primary drinking water standards

(Maximum Contaminant Levels or MCLs) established under the Safe Drinking Water Act (SDWA), and the drinking water supplied from the Roubidoux at the site is safe for all uses. Nonetheless, all available information indicates that the primary mechanism for mine water to enter the Roubidoux aquifer is infiltration through unplugged abandoned wells or infiltration through wells that have faulty well casings and/or poor seals across the Boone Formation; consequently, it is essential that plugging of abandoned wells continue.

3. **ODEQ research has found references to 19 abandoned wells that need to be assessed for plugging (this issue is carried over from the third five-year review).** The OU1 ROD recognized that additional abandoned wells completed in the Roubidoux aquifer might be identified after completion of the OU1 RA. The ROD stated that the need to plug additional wells would be evaluated as wells were identified. The existence of the wells found by ODEQ's research in historic documents has not been verified. Field work will be necessary to verify the existence of these wells and to determine whether they are completed in the Roubidoux aquifer.
4. **While significant progress has been made, there is work remaining before the OU2 RA is complete (this issue is carried over from the third five-year review).** Residential yard remediation has been completed in the towns of Picher, Quapaw, North Miami, and Cardin. However, additional work is still necessary to complete the RA for OU2. Chat has been identified in driveways and alleyways in Miami and in other areas of Ottawa County outside of the mining area. The footprints of homes demolished and removed as part of the OU4 voluntary relocation, the footprints of homes demolished in Miami due to flooding issues, and the footprints of homes demolished as part of work performed in Commerce have not been assessed to determine if additional remediation is required.
5. **An assessment of the surface water and sediment data for Tar Creek should be completed to verify that a threat to human health does not exist (this issue is carried over from the third five-year review).** The third five-year review recommended that then current surface water and sediment data for Tar Creek be evaluated to verify that no threat to human health exists in Tar Creek. Since the third five-year review, additional studies have been conducted. These additional studies gathered additional data on the surface water and sediment in site streams, including Tar Creek. The studies also gathered data from fish tissue. Based on this data, the assumptions on which the OU1 ROD fund balancing ARAR's waiver were based are no longer valid. The OU1 ROD stated that fillets of fish caught from the mouth of Tar Creek, the Spring and Neosho Rivers, and Grand Lake were safe to eat. However, recent ODEQ data have demonstrated that potential risk to human health exists through consumption of fish caught from Tar Creek, the Spring and Neosho Rivers, and Grand Lake. The OU1 ROD also stated that the sediments in Tar Creek provide a long-term sink for metals that

effectively removes the metals from most biological processes. However, the advanced SLERA documented a moderate to high risk to ecological receptors from sediment and surface water contamination associated with the site. Data from ongoing OU5 investigations of surface water and sediment show that metals concentrations in surface water in site streams continue to exceed the OWQS for its lowered designated beneficial uses.

6. **Institutional Controls (ICs) restricting the use of shallow ground water have not been put in place as called for in the OU4 ROD.** The OU4 ROD calls for ICs restricting the use of the Boone aquifer and also restricting the use of any ground water that is shallower than the Boone. Specifically, the ROD calls for ICs restricting the potable and domestic use of such ground water where concentrations of site-related contaminants exceed the remediation goals established in the ROD. The IC is to be implemented through the OWQS (785 Oklahoma Administrative Code [OAC] 45 Appendix H). Appendix H of the OWQS states that toxic metals are present and that special well construction methods are required within the OU4 boundary due to contamination in the Boone aquifer, but there are currently no limitations placed on the use of ground water from the Boone aquifer (or other shallower ground water) for potable use, including domestic supply.

The following recommendations and follow-up actions have been identified to address these issues:

1. **Develop an O&M Plan for the dike and diversion channel at the Admiralty site.** The ODEQ indicated in the third five-year review that the last O&M Plan developed for the diversion dike and channel at the Admiralty Mine Site was prepared in 1987 and new facts may have made it outdated. The O&M Plan prepared for the Admiralty Mine Site should be updated. Maintenance needs to be performed to the dike at the Admiralty site. The maintenance items identified during the fourth five-year review site inspection should be performed. ODEQ should provide to EPA a schedule that indicates when the O&M Plan will be revised and when the necessary maintenance will be completed. This follow-up action should be completed no later than September 2012.
2. **Complete the evaluation of the effectiveness of the well plugging program that is intended to prevent mine water infiltration into the Roubidoux aquifer.** It would be beneficial to future long-term decision making if, under the Roubidoux Ground Water Monitoring Program, all the analytical results available from the Roubidoux aquifer were compiled into a single database. The database could then be used to perform statistical and trend analyses on the data to assess long-term changes to the water quality of the Roubidoux. If additional data are required to complete the evaluation, then such data should be collected. Recommendations should then be developed regarding the need for continued monitoring and/or additional actions to protect the Roubidoux aquifer if necessary. The

evaluation of the effectiveness of the well plugging program should be completed by September 2014 (prior to the next five-year review).

- 3. Undertake field work to determine whether the 19 wells that ODEQ found in literature actually exist, and evaluate whether plugging any wells found is warranted or feasible.** Each well location the ODEQ found in literature should be investigated, located, assessed, and if necessary and technically feasible, plugged in accordance with the OU1 ROD. As additional potential abandoned well locations are found, field work should be undertaken to locate any wells that exist. If any wells are found, ODEQ should determine whether the well is completed in the Roubidoux aquifer, and ODEQ should plug those abandoned wells completed in the Roubidoux aquifer where it is found to be technically feasible to do so. EPA will assist ODEQ to plug as many wells as can be located. This follow-up action should be completed by September 2012.
- 4. Remaining actions should be taken to complete the OU2 RA.** These actions include, but may not be limited to: 1) assessment of chat in driveways and alleyways in areas of Ottawa County, including Miami, that are outside of the mining area (approximately 450 in Miami and 50 in other areas of Ottawa County); 2) assessment of the footprints of homes demolished as part of the voluntary relocation (approximately 450 properties); 3) remediation of residential properties located outside of the boundary of the OU4 voluntary buyout, where access was previously denied, and where soil lead concentrations exceed the remediation goal established in the OU2 ROD (approximately 140 properties). Owners of residential properties where access was previously denied will be offered a final opportunity to have their property re-sampled and remediated if necessary. The next five-year review should also consider whether OU2 can be deleted from the National Priorities List (NPL). This deletion of OU2 from the NPL would be a partial deletion of the site. This follow-up action should be completed by September 2015.
- 5. The EPA should complete the evaluation of current surface water and sediment data for Tar Creek to verify that no unacceptable risks to human health and the environment exist in Tar Creek.** Numerous studies have been conducted since the third five-year review. These studies have collected surface water and sediment data in Tar Creek and other site streams. If necessary, the EPA should collect enough additional data to determine whether potential risks are posed to human health and the environment by the surface water and sediments in streams of the Tar Creek site. The risks should be quantified through a risk assessment. If unacceptable risks are identified, then potential remedial alternatives will be evaluated to address the identified risks. Potential remedial alternatives may include engineered remedies, such as passive treatment through constructed wetlands. A determination may also be made that it is still technically impractical to address surface water and

sediment through an engineered remedy and/or that no further action is required. The risk assessment portion of this follow-up action should be completed by September 2012. If necessary, an evaluation of remedial alternatives should be completed by September 2014 (prior to the next five-year review).

- 6. The IC restricting potable and domestic use of shallow ground water including the Boone aquifer as specified in the OU4 ROD should be implemented.** The OU4 ROD calls for ICs restricting the use of the Boone aquifer and also restricting the use of any ground water that is shallower than the Boone. Specifically, the ROD calls for ICs restricting the potable and domestic use of such ground water where concentrations of site-related contaminants exceed the remediation goals established in the ROD. The IC is to be implemented through the OWQS (785 OAC 45 Appendix H). Appendix H of the OWQS states that toxic metals are present and that special well construction methods are required within the OU4 boundary due to contamination in the Boone aquifer, but there are currently no limitations placed on the use of ground water from the Boone aquifer (or other shallower ground water) for potable use, including domestic supply. The ODEQ has indicated that it will explore placing a restriction in Appendix H of the OWQS limiting ground water use from the mine pool and the Boone aquifer in the immediate vicinity of the mine pool for public water supply, or domestic use. The ODEQ's restriction will include treatment requirements to remove any lead above the MCL of 15 micrograms per liter. EPA suggests that the State of Oklahoma review this IC. This follow-up action should be completed by September 2011.

Five-Year Review Summary Form

SITE IDENTIFICATION

Site name (from WasteLAN): Tar Creek Superfund Site

EPA ID (from WasteLAN): OKD980629844

Region: United States Environmental Protection
Agency (EPA) Region 6

State:
Oklahoma
and Kansas

City/County:
Ottawa County plus Treece, Kansas

SITE STATUS

NPL Status: ☒ Final ☐ Deleted ☐ Other (specify):

Remediation status (choose all that apply): ☒ Under Construction ☒ Operating ☐ Complete

Multiple OUs? ☒ Yes ☐ No

Construction completion date: The OU1 dikes were completed in Dec. 1986

Has site been put into reuse? ☒ Yes (partially) ☐ No

REVIEW STATUS

Reviewing agency: ☒ EPA ☐ State ☐ Tribe ☐ Other Federal Agency:

Author: EPA Region 6, with support from Remedial Action Contract 2 (RAC2) contractor CH2M HILL, Inc.

Review period: September 2005 through January 2010

Date(s) of site inspection: December 14 and 15, 2009

Type of review: ☒ Statutory
☐ Policy
☐ Post-SARA ☐ Pre-SARA ☐ NPL-Removal only
☐ Non-NPL Remedial Action Site ☐ NPL State/Tribe-lead
☐ Regional Discretion

Review number: ☐ 1 (first) ☐ 2 (second) ☐ 3 (third) ☒ Other (specify): 4 (fourth)

Triggering action: ☐ Actual RA On-site Construction ☐ Actual RA Start
☐ Construction Completion ☐ Recommendation of Previous
☒ Other (specify): Previous Five-Year Review Report

Triggering action date (from WasteLAN): September 28, 2005 (date Third Five-Year Review Report was signed).

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Issues: The operation and maintenance (O&M) and Roubidoux Ground Water Monitoring Program for Operable Unit (OU) 1, the OU2 Remedial Action (RA), and the OU4 Remedial Design (RD) and RA are ongoing at the site. Based on the fourth five-year review data review, site inspection, interviews and technology assessment, it appears the selected remedies are functioning in a manner that is consistent with the decision documents (except as noted regarding the dikes and diversion work portions of the OU1 remedy which are not significantly reducing mine water discharges to Tar Creek). To ensure continued protectiveness, six issues are identified in the following paragraphs.

The first five issues described below are carried over from the third five-year review. Of these, the first four do not currently affect the protectiveness, but they should be addressed to ensure continued protectiveness of the selected remedies. The fifth issue currently affects protectiveness in that current data indicates that potential unacceptable risks to human health and the environment are posed by surface water and sediment at the site. However, a formal evaluation of the data through the risk assessment process is necessary to assess potential human health risks that might exist. The advanced Screening Level Ecological Risk Assessment (SLERA) performed under OU5 has demonstrated that environmental risks are present in site sediments and surface water, but a determination of whether or not the risks are unacceptable has not been made.

The sixth issue currently affects protectiveness in that Appendix H of the Oklahoma Water Quality Standards (OWQS), 785 Oklahoma Administrative Code (OAC) 45 does not address restrictions on the use of ground water from the Boone aquifer and shallower ground water in areas impacted above remediation goals as called for in the OU4 Record of Decision (ROD).

1. **No O&M Plan exists for the dike and diversion channel for the Admiralty Mine Site (this issue is carried over from the third five-year review).** The Oklahoma Department of Environmental Quality's (ODEQ) O&M Plan for the dike and diversion channel constructed at the Admiralty Mine Site as part of the OU1 remedy was written in 1987 and facts have arisen that make it outdated. The ODEQ is responsible for maintaining the dike and diversion channel at the Admiralty Mine Site, as part of ODEQ's O&M for OU1. The dike at the Admiralty site requires some maintenance to repair damage noted during the site inspection and mowing.
2. **A determination regarding the effectiveness of the well plugging program, which was intended to prevent mine water infiltration into the Roubidoux aquifer has not been completed (this issue is carried over from the third five-year review).** The Roubidoux Ground Water Monitoring Program has collected data for a period of over 20 years since the RA to plug abandoned Roubidoux wells was completed. In the past, it was believed that the Roubidoux aquifer was being impacted by the mine water; however, only certain indicator parameters were found, and subsequent data collection over twenty years has not found any more reason to believe that the mine water is degrading the Roubidoux. It should be noted that neither the United States Environmental Protection Agency (EPA) nor ODEQ have identified any public drinking water wells at the site that fail to meet the health-based primary drinking water standards (Maximum Contaminant Levels or MCLs) established under the Safe Drinking Water Act (SDWA), and the drinking water supplied from the Roubidoux at the site is safe for all uses. Nonetheless, all available information indicates that the primary mechanism for mine water to enter the Roubidoux aquifer is infiltration through unplugged abandoned wells or infiltration through wells that have faulty well casings and/or poor seals across the Boone Formation; consequently, it is essential that plugging of abandoned wells continue.
3. **ODEQ research has found references to 19 abandoned wells that need to be assessed for plugging (this issue is carried over from the third five-year review).** The OU1 ROD recognized that additional abandoned wells completed in the Roubidoux aquifer might be identified after completion of the OU1 RA. The ROD stated that the need to plug additional wells would be evaluated as wells were identified. The existence of wells found by ODEQ's research in historic documents has not been verified. Field work will be necessary to verify the existence of these wells and to determine whether they are completed in the Roubidoux.
4. **While significant progress has been made, there is work remaining before the OU2 RA is complete (this issue is carried over from the third five-year review).** Residential yard remediation has been completed in the towns of Picher, Quapaw, North Miami, and Cardin. However, additional work is still necessary to complete the RA for OU2. Chat has been identified in driveways and alleyways in Miami and in other areas of Ottawa County outside of the mining area. The footprints of homes demolished and removed as part of the OU4 voluntary relocation, the footprints of homes demolished in Miami due to flooding issues, and the footprints of homes demolished as part of work performed in Commerce have not been assessed to determine if additional remediation is required.

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5. **An assessment of the surface water and sediment data for Tar Creek should be completed to verify that a threat to human health does not exist (this issue is carried over from the third five-year review).** The third five-year review recommended that then current surface water and sediment data for Tar Creek be evaluated to verify that no threat to human health exists in Tar Creek. Since the third five-year review, additional studies have been conducted. These additional studies gathered additional data on the surface water and sediment in site streams, including Tar Creek. These studies also gathered data from fish tissue. Based on this data, the assumptions on which the OU1 ROD fund balancing applicable or relevant and appropriate requirements (ARAR's) waiver were based are no longer valid. The OU1 ROD stated that fillets of fish caught from the mouth of Tar Creek, the Spring and Neosho Rivers, and Grand Lake were safe to eat. However, recent ODEQ data have demonstrated that potential risk to human health exists through consumption of fish caught from Tar Creek, the Spring and Neosho Rivers, and Grand Lake. The OU1 ROD also stated that the sediments in Tar Creek provide a long-term sink for metals that effectively removes the metals from most biological processes. However, the advanced SLERA documented a moderate to high risk to ecological receptors from sediment and surface water contamination associated with the site. Data from ongoing OU5 investigations of surface water and sediment show that metals concentrations in surface water in site streams continue to exceed the OWQS for its lowered designated beneficial uses.
6. **Institutional controls (ICs) restricting the use of shallow ground water have not been put in place as called for in the OU4 ROD.** The OU4 ROD calls for ICs restricting the use of the Boone aquifer and also restricting the use of any ground water that is shallower than the Boone. Specifically, the ROD calls for ICs restricting the potable and domestic use of such ground water where concentrations of site-related contaminants exceed the remediation goals established in the ROD. The IC is to be implemented through the OWQS (785 OAC 45 Appendix H). Appendix H of the OWQS states that toxic metals are present and that special well construction methods are required within the OU4 boundary due to contamination in the Boone aquifer, but there are currently no limitations placed on the use of ground water from the Boone aquifer (or other shallower ground water) for potable use, including domestic supply.

Recommendations and Follow-up Actions: To address the issues identified during the fourth five-year review, the following recommendations and follow-up actions have been identified for the site:

1. **Develop an O&M Plan for the dike and diversion channel at the Admiralty site.** The ODEQ indicated in the third five-year review that the last O&M Plan developed for the diversion dike and channel at the Admiralty Mine Site was prepared in 1987 and new facts may have made it outdated. The O&M Plan prepared for the Admiralty Mine Site should be updated. Maintenance needs to be performed to the dike at the Admiralty site. The maintenance items identified during the fourth five-year review site inspection should be performed. ODEQ should provide to EPA a schedule that indicates when the O&M Plan will be revised and when the necessary maintenance will be completed. This follow-up action should be completed no later than September 2012.
2. **Complete the evaluation of the effectiveness of the well plugging program that is intended to prevent mine water infiltration into the Roubidoux aquifer.** It would be beneficial to future long-term decision making if, under the Roubidoux Ground Water Monitoring Program, all the analytical results available from the Roubidoux aquifer were compiled into a single database. The database could then be used to perform statistical and trend analyses on the data to assess long-term changes to the water quality of the Roubidoux. If additional data are required to complete the evaluation, then such data should be collected. Recommendations should then be developed regarding the need for continued monitoring and/or additional actions to protect the Roubidoux aquifer if necessary. The evaluation of the effectiveness of the well plugging program should be completed by September 2014 (prior to the next five-year review).
3. **Undertake field work to determine whether the 19 wells that ODEQ found in literature actually exist, and evaluate whether plugging any wells found is warranted or feasible.** Each well location the ODEQ found in literature should be investigated, located, assessed, and if necessary and technically feasible, plugged in accordance with the OU1 ROD. As additional potential abandoned well locations are found, field work should be undertaken to locate any wells that exist. If any wells are found, ODEQ should determine whether the well is completed in the Roubidoux aquifer, and ODEQ should plug those abandoned wells completed in the Roubidoux aquifer where it is found to be technically feasible to do so. EPA will assist ODEQ to plug as many wells as can be located. This follow-up action should be completed by September 2012.

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4. **Remaining actions should be taken to complete the OU2 RA.** These actions include, but may not be limited to: 1) assessment of chat in driveways and alleyways in areas of Ottawa County, including Miami, that are outside of the mining area (approximately 450 in Miami and 50 in other areas of Ottawa County); 2) assessment of the footprints of homes demolished as part of the voluntary relocation (approximately 450 properties); 3) remediation of residential properties located outside of the boundary of the OU4 voluntary buyout, where access was previously denied and where soil lead concentrations exceed the remediation goal established in the OU2 ROD (approximately 140 properties). Owners of residential properties where access was previously denied will be offered a final opportunity to have their properties re-sampled and remediated if necessary. The next five-year review should also consider whether OU2 can be deleted from the National Priorities List (NPL). This deletion of OU2 from the NPL would be a partial deletion of the site. This follow-up action should be completed by September 2015.
5. **The EPA should complete the evaluation of current surface water and sediment data for Tar Creek to verify that no unacceptable risks to human health and the environment exist in Tar Creek.** Numerous studies have been conducted since the third five-year review. These studies have collected surface water and sediment data in Tar Creek and other site streams. If necessary, the EPA should collect enough additional data to determine if potential risks are posed to human health and the environment by the surface water and sediments in streams of the Tar Creek site. The risks should be quantified through a risk assessment. If unacceptable risks are identified, then potential remedial alternatives will be evaluated to address the identified risks. Potential remedial alternatives may include engineered remedies, such as passive treatment through constructed wetlands. A determination may also be made that it is still technically impractical to address surface water and sediment through an engineered remedy and/or that no further action is required. The risk assessment portion of this follow-up action should be completed by September 2012. If necessary, an evaluation of remedial alternatives should be completed by September 2014 (prior to the next five-year review).
6. **The IC restricting potable and domestic use of shallow ground water including the Boone aquifer as specified in the OU4 ROD should be implemented.** The OU4 ROD calls for ICs restricting the use of the Boone aquifer and also restricting the use of any ground water that is shallower than the Boone. Specifically, the ROD calls for ICs restricting the potable and domestic use of such ground water where concentrations of site-related contaminants exceed the remediation goals established in the ROD. The IC is to be implemented through the OWQS (785 OAC 45 Appendix H). Appendix H of the OWQS states that toxic metals are present and that special well construction methods are required within the OU4 boundary due to contamination in the Boone aquifer, but there are currently no limitations placed on the use of ground water from the Boone aquifer (or other shallower ground water) for potable use, including domestic supply. The ODEQ has indicated that it will explore placing a restriction in Appendix H of the OWQS limiting ground water use from the mine pool and the Boone aquifer in the immediate vicinity of the mine pool for public water supply or domestic use. The ODEQ's restriction will include treatment requirements to remove any lead above the MCL of 15 micrograms per liter. EPA suggests that the State of Oklahoma review this IC. This follow-up action should be completed by September 2011.

Protectiveness Statement(s): The remedies implemented for the Tar Creek Superfund Site are protective of human health and the environment, except as noted in this five-year review regarding the need for further assessment of potential surface water and sediment impacts on human health and the environment.

The OU1 remedy addressed the primary route of potential human exposure by protecting the Roubidoux aquifer, and, in this way, preventing the possibility that hazardous substances would be ingested in drinking water. Sampling data indicate that the Roubidoux aquifer continues to meet all health-based primary drinking water standards at currently operating municipal wells.

Some of the exposure assumptions and the potential risks posed to human health and the environment for surface water and sediments at the site that were stated in the OU1 ROD are no longer valid. Recent fish tissue data collected by ODEQ demonstrate that potential risks to human health exist through consumption of fish caught from Tar Creek, the Spring and Neosho Rivers, and Grand Lake. Metals contained within site sediments are biologically available and pose risks to ecological receptors. The concentrations of site-related contaminants in Tar Creek surface water continue to exceed the OWQS. The narrative and numerical criteria in the OWQS are designed to maintain and protect the beneficial surface water use classification of "Fish and Wildlife Propagation". Under the OWQS there are numerical "Toxic Substance" concentration limits for surface water with both "acute" and "chronic" standards listed. Under 785 OAC 45 OWQS, "acute toxicity" means the surface water concentration of a toxic substance is such that it means greater than or equal to 50% lethality to appropriate test organisms in a test sample. Under those same standards,

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"chronic toxicity" means the surface water concentration of a toxic substance is such that there is a statistically significant difference (at the 95% confidence level) between longer-term survival and/or reproduction or growth of the appropriate test organisms in a test sample and a control. Teratogenicity and mutagenicity are considered to be effects of chronic toxicity. In Tar Creek, Lytle Creek, and Elm Creek at the Tar Creek Site, EPA found that cadmium, lead, and zinc concentrations in surface water samples exceed the OWQS chronic toxicity standard, and zinc concentrations also exceed the acute toxicity standard. Finally, initial construction costs for the constructed passive wetland southeast of Commerce are considered reasonable and may be an economically feasible engineered remedy for contaminated surface water at the site. Long-term O&M costs for such a passive wetlands system still require further evaluation. For these reasons, the fund balancing ARARs waiver contained in the OU1 ROD may no longer be appropriate, and should be reevaluated.

The remedy being implemented for OU2 is protective of human health and the environment in all areas where remediation has been completed. A total of over 2,295 properties have been remediated during the OU2 RA and during the removal actions that preceded the RA. Remaining items needed to complete the remedy are being evaluated. The RA for OU2 is ongoing and is scheduled to be completed by the next five-year review. Human health and the environment are being protected by the remedy for OU2.

The action implemented during the Removal Action for OU3 is protective of human health and the environment. The laboratory chemicals left at the former Eagle-Picher Office Complex were removed from the site and properly disposed of.

The RD and RA for OU4 are currently being conducted. The voluntary relocation is in progress and anticipated to be completed in 2010, and chat sales continue at the site. Under OU4, Appendix H of the OWQS 785 OAC 45 does not limit use of the ground water from the Boone aquifer as called for in the OU4 ROD. The OU4 Remedial Investigation (RI) identified 13 private wells completed in the Boone aquifer at the site that were being used as a source of drinking water. Of the 13 wells, testing showed that concentrations of site-related contaminants exceeded remediation goals in only two of the on-site private wells. The OU4 ROD includes provisions for these two residences to be provided with an alternate drinking water supply as part of the OU4 RA. Action to address the IC in the OU4 ROD with respect to restricting potable and domestic use of shallow ground water and ground water from the Boone aquifer still need to be taken. The OU4 remedy will be protective of human health and the environment once completed.

Investigations are currently being conducted for OU5.

With the exceptions noted above for OU1, the completed RAs, Roubidoux Ground Water Monitoring Program, and O&M activities for the Tar Creek Superfund Site are all protective for the short term due to the implementation of the 2008 fish consumption advisory for OU1 and because the population most at risk has been relocated under OU4. The remedies will continue to be protective in the long-term if the action items identified in this five-year review are addressed and the remedies are implemented as selected in the RODs.

Other Comments: The selected remedy for OU4 is anticipated to require 30 years to complete. The voluntary relocation is in progress and anticipated to be completed in 2010. The RD/RA for portions of the selected remedy began in 2009. OU5 is currently being investigated.

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Fourth Five-Year Review Report Tar Creek Superfund Site

The United States Environmental Protection Agency (EPA) Region 6 has conducted a fourth five-year review of the remedial actions (RAs) implemented at the Tar Creek Superfund Site (“site”), for the period between September 2005 (when the third five-year review was completed) to January 2010. The purpose of a five-year review is to determine whether the remedy at a site remains protective of human health and the environment, and to document the methods, findings, and conclusions of the five-year review in a five-year review report. Five-year review reports identify issues found during the review, if any, and make recommendations to address the issues. This fourth five-year review report documents the results of the review for the Tar Creek Superfund Site, conducted in accordance with EPA guidance on five-year reviews.

The Tar Creek Superfund Site is primarily located in Ottawa County, Oklahoma, in the far northeastern corner of the state. It consists of five Operable Units (OUs): OU1 (surface water/ground water); OU2 (residential properties and High Access Areas [HAAs]); OU3 (Eagle-Picher Office Complex – abandoned mining chemicals); OU4 (chat piles, other mine and mill waste, and smelter waste); and OU5 (sediment and surface water). Treece, Kansas was included in OU4 through an Explanation of Significant Difference (ESD) signed by EPA in April 2010. The ESD explains that, consistent with the OU4 ROD, EPA has decided to complete a voluntary relocation of residents in Treece, Kansas as part of the OU4 remedial action (RA) (**EPA, 2010b**).

EPA guidance on conducting five-year reviews is provided by the Office of Solid Waste and Emergency Response (OSWER) Directive 9355.7-03B-P, *Comprehensive Five-Year Review Guidance* (**EPA, 2001**) (replaces and supercedes all previous guidance on conducting five-year reviews).

1.0 Introduction

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 United States Code (USC) ' 9601 *et seq.* and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300 *et seq.*, call for five-year reviews of certain CERCLA RAs. The statutory requirement to conduct a five-year review was added to CERCLA as part of the Superfund Amendments and Reauthorization Act of 1986 (SARA), P.L. 99-499. The EPA may also conduct five-year reviews as a matter of policy for sites not addressed specifically by the statutory requirement. The EPA classifies each five-year review as either “statutory” or “policy” depending on

whether it is being required by statute or is being conducted as a matter of policy. The fourth five-year review for the Tar Creek Superfund Site is a statutory review.

As specified by CERCLA and the NCP, statutory reviews are required for sites where, after RAs are complete, hazardous substances, pollutants, or contaminants will remain on site at levels that will not allow for unrestricted use or unrestricted exposure. Statutory reviews are required for such sites if the Record of Decision (ROD) was signed on or after the effective date of SARA. CERCLA §121(c), as amended, 42 USC § 9621(c), states:

If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented.

The implementing provisions of the NCP, as set forth in the CFR, state at 40 CFR 300.430(f)(4)(ii):

If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

The EPA five-year review guidance further states that a five-year review should be conducted as a matter of policy for the following types of actions:

- A pre-SARA RA that leaves hazardous substances, pollutants, or contaminants on-site above levels that allow for unlimited use and unrestricted exposure;
- A pre or post SARA RA that, once completed, will not leave hazardous substances, pollutants, or contaminants on site above levels that allow for unlimited use and unrestricted exposure but will require more than five years to complete; or,
- A removal-only site on the National Priorities List (NPL) where the removal action leaves hazardous substances, pollutants, or contaminants on site above levels that allow for unlimited use and unrestricted exposure and no RA has or will be conducted (**EPA, 2001**).

This five-year review for the Tar Creek Superfund Site is required by statute. The EPA signed an Explanation of Significant Difference (ESD) for the OU2 ROD in August 2007 that requires a statutory five-year review of the OU2 remedy. Previous five-year reviews for the site were conducted as a matter of EPA policy because the ROD for OU1 was signed prior to the effective date of SARA, and the original OU2 ROD stipulated that a five-year review was not required. Actions associated with OU3, OU4, and OU5 are also described by this five-year review report, as components of the Tar Creek Superfund Site.

This is the fourth five-year review for the Tar Creek Superfund Site. The first five-year review was completed in April 1994; the second five-year review was completed in April 2000; and the third five-year review was completed in September 2005. The triggering action for this statutory review is the date the third five-year review report was signed on September 28, 2005.

2.0 Site Chronology

A chronology of significant site events and dates is included in [Table 1](#), provided at the end of the report text. Sources of this information are listed in [Attachment 1, Documents Reviewed](#).

3.0 Background

This section describes the physical setting of the site, including a description of the land use, resource use, and environmental setting. This section also describes the history of contamination associated with the site, the initial response actions taken at the site, and the basis for each of the initial response actions. RAs performed subsequent to the initial response actions for each of the OUs defined for the site are described in [Section 4](#).

3.1 Physical Characteristics

The Tar Creek Superfund Site is primarily located in Ottawa County, Oklahoma, in the far northeastern corner of the state (see [Figure 1](#) for a site map). In April 2010, EPA decided to add Treece, Kansas, to the site. Specifically, EPA decided to relocate the residents of Treece to help prevent exposure to the source material deposits at Tar Creek. The decision to relocate the residents of Treece was documented in an ESD to the OU4 ROD issued in April 2010 ([EPA, 2010b](#)). The Tar Creek Superfund Site has no distinct boundaries, but it includes the Oklahoma portion of the Tri-State Mining District (TSMD) along with other areas in Ottawa County where mining waste has come to be located. The TSMD is located in the border region of Kansas, Missouri, and Oklahoma. The Picher Field was the Oklahoma portion of the TSMD centered on the town of Picher, Oklahoma. Extensive lead and zinc mining took place in the

Picher Field between the early 1900's and the 1970's. The Tar Creek Superfund Site is about 40 square miles in size. The principal communities within the mining area include Picher, Quapaw, Cardin, Commerce, and North Miami. The residents of Picher and Cardin were relocated under OU4 and those communities are now generally abandoned. The contamination at the site resulted from past mining activities. The Cherokee County Superfund Site in Kansas and the Oronogo-Duenweg and Newton County Superfund Sites in Missouri comprise the Kansas and Missouri portions of the TSMD (**EPA, 1994a**).

Tar Creek and its primary tributary Lytle Creek comprise the principal drainage system within the Picher Field. Tar Creek is characterized as a small ephemeral stream with standing pools. The headwaters of Tar Creek are located in Cherokee County, Kansas (located north of Ottawa County on the Kansas-Oklahoma border). Tar Creek then flows southward through the Picher Field between the towns of Picher and Cardin, to the east of Commerce and Miami, and it then flows to its confluence with the Neosho River. Tar Creek and Lytle Creek drain approximately 53 square miles. Other principal drainage features near the site in Ottawa County include the Neosho River (located south of the site), the Spring River (located east of the site), and Grand Lake (located in southern Ottawa County) (**EPA, 1994a**).

The Picher Field (including most of the Tar Creek Superfund Site) is located on the eastern edge of the Central Lowland Provinces. Eastern portions of the site are located in the Ozark Plateau. The Central Lowland Province is a nearly flat, treeless prairie. The Ozark Plateau is a broad, low structure dome centered in southwestern Missouri and northwestern Arkansas. The natural land surface at the site is mostly flat and gently slopes to the south towards the Neosho River, to the east towards the Spring River, and to the west towards Elm Creek. However, much of the land surface has been modified by the mining activities. There are numerous large tailings piles, composed of primarily limestone and chert, present on the land surface. In addition, numerous collapsed structures from subsidence and cave-ins of mine shafts are also present on the land surface (**EPA, 1984**).

Contaminated ground water at the site occurs within the Boone Formation (also known as the Boone aquifer). The Boone Formation is composed primarily of limestone, dolomite, and chert, with lesser amounts of sandstone and shale. Lead and zinc ore were mined from various members of the Boone Formation. Within the mining area, water quality within the Boone aquifer is poor due to acidity and high dissolved metals concentrations. The Boone aquifer is not used as a primary source of drinking water at the site. However, the OU4 RI did identify 13 private residential wells completed in the Boone aquifer that were being used as a source of drinking water at the site. Of the 13 wells tested during the RI,

only two were found to be impacted above the Final Remediation Goals. The OU4 ROD includes provisions for these two residences to be provided with an alternate drinking water supply as part of the OU4 RA (EPA, 2008). Outside of the mining district, the Boone aquifer is used as a primary drinking water source. In areas where the Boone Formation outcrops at the surface, the aquifer is unconfined. Where the Boone Formation is overlain by confining strata, the aquifer is confined. At the Tar Creek Superfund Site, the Boone aquifer is both unconfined and confined. In the southern portion of the site, the potentiometric surface within the aquifer exceeds the land surface elevation. This results in artesian conditions, and ground water discharges from abandoned wells, boreholes, mine shafts, and collapse structures. This ground water is acidic and contains high metals concentrations, and hence it is referred to as acid mine water or acid mine drainage. This discharge then flows into Tar Creek (EPA, 1994a).

Also of interest at the site is the Roubidoux aquifer. The Roubidoux aquifer is composed of cherty limestone with several sand sequences near its base. The Roubidoux aquifer lies beneath the Boone aquifer, and the two are separated by 410 feet to 520 feet of limestone and shale of the Chattanooga Shale, the Jefferson City Dolomite, and the Cotter Dolomite. Where present, the Chattanooga Shale acts as an aquitard and restricts ground water flow between the Boone aquifer and Roubidoux aquifer. The Chattanooga Shale is absent in most portions of the site. Hydrologically, the Cotter and Jefferson City Dolomites are considered a part of the Roubidoux aquifer (ODEQ, 2006c). The Roubidoux aquifer is a major source of drinking water in the area of the site (EPA, 1994a). The cities of Quapaw, Commerce, Miami (located south of the site), and several rural water districts obtain their water supplies from the Roubidoux aquifer (EPA, 1984).

3.2 Land and Resource Use

Land ownership at the site can be classified as private or Indian-owned. Under an 1833 treaty, the United States set aside the Quapaw Reserve, located in Ottawa County, Oklahoma, consisting of approximately 12,600 acres of land. A majority of these lands are individually owned allotted lands with ‘restrictions against alienation.’ These lands are managed under the supervision of the United States Bureau of Indian Affairs (BIA) (BIA, 2005).

Due to the size of the site, land use is varied. The site encompasses residential, commercial, and industrial areas within the towns, while most of the land use outside of the towns is agricultural (EPA, 1997). Approximately 19,500 people lived in the mining area or close proximity to the mining area (EPA, 2008). Tar Creek flows approximately through the center of the site, and it discharges into the Neosho River south of the site. The Neosho River discharges into Grand Lake in southern Ottawa

County. Ground water under the site is found within both the Boone aquifer and Roubidoux aquifer. The Boone aquifer at the site is not currently used as a drinking water supply, but there are some private wells completed within the Boone aquifer. The Roubidoux aquifer is regionally used as a water supply (**EPA, 1994a**).

3.3 History of Contamination

Lead and zinc mining activities first began at the site in the early 1900's. During the early mining period, most mining was conducted by small operators on 20 to 40 acre tracts. Each operator conducted their own mining, drilling, and milling activities (**EPA, 1984**). Mining activities occurred within a 50 to 150 foot thick ore bearing zone within the Boone Formation. The maximum depth of mining was approximately 385 feet below ground surface. Mining was accomplished using room and pillar techniques. To remove the ore, large rooms, some with ceilings as high as 100 feet, were connected by horizontal tunnels known as drifts. Pillars were left within the rooms to support the ceilings (**EPA, 1994a**). The lead and zinc ores were milled locally and generally sent to locations outside of Ottawa County for smelting (the small smelter that operated in Hockerville is an exception). Rapid expansion of mining activities occurred during the 1920's, and mining activities reached their peak around 1925. Each mine holding usually had its own mill. During the 1930's, large central mills came into operation, and most mining operations ceased operating their own mills. During the peak of mining activities, 130,410 tons of lead and 749,254 tons of zinc were produced annually. Large scale underground mining activities ended in 1958 (**Brown and Root, 1997**). Smaller mining operations continued in the Picher Field through the 1960's, and all mining activities at the site ceased in the 1970's (**EPA, 2000b**).

Zinc smelting operations were not known to have occurred in the Tar Creek area. Lead smelting of the material mined in the Tar Creek area was dominated by the Eagle-Picher Company, which operated a smelter in nearby Joplin, Missouri. However, the Ontario Smelting Company did operate a lead smelter near Hockerville, Oklahoma. Ontario Smelting Company operated this smelter from 1918 until 1924. The smelter was then purchased by the Eagle-Picher Company, who operated the smelter until the early 1930's, when the smelting operations ceased. There were no other smelting operations known to have occurred in the Tar Creek area (**USACE, 2002**).

Ground water infiltration into the mines was a continual problem. This ground water inflow was controlled through the use of pumps (**EPA, 1984**). When mining operations ceased, it is estimated that underground cavities with a volume of 100,000 acre-feet (161,000,000 cubic yards) had been created. In addition, approximately 100,000 exploratory boreholes were located within the Picher Field, mostly in

Oklahoma. 1,064 mine shafts existed within the Oklahoma portion of the mining district. In addition, numerous water wells, used for milling operations, were abandoned (**EPA, 2000b**).

During the active mining period, large scale pumping had created a large cone of depression, effectively dewatering the Boone aquifer in the mining area. Exposed sulfide minerals, primarily marcasite and pyrite (both iron sulfide), were oxidized by exposure to the moist air in the mines. When mining activities ceased, pumping was also ceased, and the abandoned mines began to flood. The oxidized sulfide minerals were now much more soluble in water. As the mines filled with ground water, the oxidized sulfide minerals began to dissolve, generating acid mine water. The acid mine water then reacted with the surrounding rock, and many of the metals present began to leach from the rock into the ground water. As a result, the acid mine water contained high concentrations of zinc, lead, cadmium, sulfate, and iron (**EPA, 1994a**).

In addition to the acid mine water, the mining activities at the site resulted in the accumulation on the ground surface of mining wastes. Large volume tailings piles (known locally as ‘chat’), some as high as 200 feet, were left at the site. Many of the tailings piles are still present across the site, mostly around the towns of Picher and Cardin. In addition, numerous abandoned tailings ponds that have been filled with fine sediments from milling and chat processing operations are also present at the site (**EPA, 2008**).

Three general types of mining wastes are present at the site. ‘Development’ rock is large diameter (4” to 2’) rock that was generated during the opening of mine shafts or drifts. Development rock generally poses no contamination problem. ‘Chat’ is mine tailings from the milling process. Chat contains a mixture of gravel (typically 3/8” in diameter) and finer-grained materials. ‘Fines’ are the fine-grained sediments collected in the flotation ponds (**EPA, 2000b**).

In March 2004, the chat piles at the site contained approximately 51.2 million tons of waste (**AATA, 2005**). The chat has historically been used as a source material for the concrete and asphalt industries and as a gravel source. Other uses of the chat have included railroad ballast, sandblasting and sandbag sand, roadway, driveway, alleyway, and parking lot aggregate, general fill material in residential areas, and impact absorbing material in playgrounds. Sales of chat have been a significant source of income in the local area. Based on estimates of historical aerial photographs, less than 50 percent of the original volume of chat remains in the area. The fines were collected into flotation ponds as part of the gravity separation milling process. Most of the ponds have since evaporated and are now dry. An inventory conducted in 2005 as part of the Remedial Investigation (RI) for OU4 identified 83 chat piles occupying

767 acres with 31 million cubic yards of mine waste, and 243 chat bases (or former piles) occupying 2,079 acres with an estimated 6.7 million cubic yards mine waste. Fine tailings generated from milling and washing chat were found in 63 ponds occupying 820 acres and totaled approximately 9 million cubic yards of mine waste (EPA, 2008).

3.4 Initial Response

By 1979, the abandoned mines had become completely flooded due to ground water infiltration and due to surface water inflow into the abandoned mine shaft openings and subsidence features. In low-lying areas along the southern portion of the site (near Commerce), the potentiometric surface exceeded the ground surface. This resulted in the surface discharge of acid mine water from abandoned boreholes and mine shafts (EPA, 2000b). This surface discharge then emptied into Tar Creek. As a result, most of the downstream biota in Tar Creek were killed. The bottom of the creek became stained red due to ferric hydroxide deposition, and red stains appeared on bridge abutments and cliffs in the Neosho River downstream of its confluence with Tar Creek (EPA, 1994a).

In 1980, the Governor of Oklahoma established the Tar Creek Task Force to investigate the effects of the acid mine drainage. The Task Force was composed of various local, state, and federal agencies. The OWRB was appointed as the lead state agency. The initial investigations were conducted by the Task Force in 1980 and 1981. The conclusions from the Tar Creek Task Force's studies included the following:

- There were no significant health risks associated with the air pathway at the Tar Creek Superfund Site;
- The Neosho River, Spring River, and Grand Lake could be used as a raw water source for public water supplies;
- The fish from areas sampled in these water bodies were safe for consumption; and,
- Most of the metals present in the acid mine water were precipitated out of the water and into the sediments in Tar Creek prior to its confluence with the Neosho River. The sediments in Tar Creek provided a long-term sink for metals that effectively removed them from most biological processes, and the sediments did not pose a health risk. Other than aesthetic alteration at the confluence of Tar Creek and the Neosho River, there was no impact on the Neosho River from the acid mine drainage in Tar Creek.

The Task Force identified the primary threat at the site as the potential for contamination of the Roubidoux aquifer (EPA, 1994a).

The EPA proposed the Tar Creek Superfund Site to the NPL in July 1981, based on information from the Task Force's investigations. The NPL is the list, compiled by EPA, of uncontrolled hazardous substance releases in the United States that are priorities for long-term remedial evaluation and response. On June 16, 1982, the EPA provided funding through a Cooperative Assistance Agreement with the Oklahoma State Department of Health (OSDH) to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the site. The OSDH was the overall lead agency at the site for the State of Oklahoma. The OWRB, under an interagency agreement with the OSDH, conducted the RI/FS for the site. The site was listed on the NPL on September 8, 1983. The EPA signed a ROD for the site on June 6, 1984 (**EPA, 1994a**). The remedy selected and implemented under the ROD is discussed in [Section 4](#).

In 1994, the EPA conducted the first five-year review of the Tar Creek Superfund Site. While conducting this five-year review, the Indian Health Service in Miami, Oklahoma, notified the EPA by letter of elevated blood lead levels in children routinely tested as part of their participation in the United States Department of Agriculture's (USDA) Women, Infant, and Children (WIC) program. The letter stated that 34% of the 192 children tested had blood lead levels above 10 micrograms per deciliter ($\mu\text{g}/\text{dl}$), which is the level above which the Centers for Disease Control (CDC) considers to be elevated in children. The letter stated that although location did not appear to be a factor, a majority of the children did live within 5 miles of a chat pile (**EPA, 1994a**). Also, EPA Region 7 had been conducting investigations of the Cherokee County (Kansas), and the Oronogo-Duenweg (Missouri) Superfund Sites. Data obtained from EPA Region 7's investigations indicated that mine wastes (including chat piles) represented an unacceptable risk to human health and the environment (**EPA, 1994a**).

In the summary portion of the first five-year review, EPA stated that the studies conducted for the 1984 ROD did not include a risk assessment. Risk assessment guidance had not been developed at the time the 1984 ROD was signed, and the primary emphasis at the Tar Creek Superfund Site was on ground water and surface water impacts related to the acid mine water. The first five-year review recommended that a second OU be designated at the site for the mining wastes. It was also recommended that studies be undertaken to determine the impacts of the chat piles and flotation ponds on human health and the environment. The studies were to include blood lead studies, environmental sampling of HAAs (HAAs are areas frequented or likely to be frequented by young children such as schools, playgrounds, day cares, etc.), mapping of all mine wastes, classification of surface mine wastes through environmental sampling and testing, sampling of leachate from mine wastes, and sampling of airborne particulates near mine wastes (**EPA, 1994a**). As a result of the five-year review recommendations, surface and ground water

contamination at the site became OU1, and impacts related to the mining waste, including HAAs and residential properties, became OU2 (**EPA, 2000b**).

EPA addressed HAAs and residential areas of OU2 first. From August 1994 through July 1995, the EPA conducted sampling through its removal program (the removal program is, generally speaking, the part of the Superfund program generally responsible for conducting emergency and early response activities) to determine the nature and extent of the contamination in residential areas of the site. The Phase I sampling addressed HAAs, and the Phase II sampling took place at residences that were inhabited or potentially inhabited by children. Twenty-eight HAAs and 2,070 residential properties were sampled as part of the site assessment. The data were used to complete the Baseline Human Health Risk Assessment (BHHRA) and Residential RI Reports. The BHHRA concluded that lead in soil was the primary contaminant of concern and that ingestion of contaminated soil was the only exposure pathway that posed a significant risk to human health. These activities led the EPA to conclude that the lead contaminated soil in residential areas posed an imminent and substantial endangerment to human health (**EPA, 2000b**).

Due to the concerns related to exposures to lead contaminated soil, the EPA issued an action memorandum on August 15, 1995, that authorized removal response actions at HAAs at the site (**EPA, 2000b**). The removal response action began in September 1995 and was completed in December 1995. The removal response action for the HAAs was known as the Phase I removal action. The Phase I removal action was conducted by EPA through its Emergency Response Cleanup Services (ERCS) contractor, Reidel Environmental Services, and by its Superfund Technical Assessment and Response Team (START) contractor, Ecology and Environment, Inc. (**Washington Group International, 2002**).

The removal response action involved the excavation of lead and/or cadmium contaminated surface soils with concentrations exceeding 500 parts per million (ppm) and 100 ppm respectively from 0 to 12 inches in depth and 1,000 ppm lead and/or 100 ppm cadmium from 12 to 18 inches. This means that in areas where the lead concentration exceeded 500 ppm from 0 to 12 inches and/or the cadmium concentration exceeded 100 ppm, the soil was excavated. When the lead concentration exceeded 1,000 ppm and/or the cadmium concentration exceeded 100 ppm in the 12 to 18 inch interval, then soil from that interval was also excavated. On large properties where unauthorized excavation could be controlled, such as parks and schools, the criteria were modified to 500 ppm lead and/or 100 ppm cadmium from 0 to 12 inches in depth (the 12 to 18 inch increment was dropped). When contamination remained above the cleanup levels below 18 inches, a barrier (orange construction fence material) was placed in the bottom of the excavation as a warning that contamination remained below the barrier. Each excavation was then

backfilled with clean soil. Seventeen of the 28 HAAs that were evaluated required a response action (**EPA, 2000b**).

The EPA issued an action memorandum on March 21, 1996 that authorized a removal response action at residences at the site (**EPA, 2000b**). This removal response action was known as the Phase II removal action, and it included both residential properties and HAAs. The EPA signed an Interagency Agreement (IAG) with the United States Army Corps of Engineers (USACE) to conduct the Phase II removal action. The USACE contracted with Morrison Knudson Corporation (MK) to complete the work (**USACE, 2002**).

This removal action was conducted in a similar manner to the HAAs, except that a cleanup level of 500 ppm for lead was chosen. This cleanup level was based on the BHHRA and EPA Region 6 experience at other lead cleanup sites. Approximately 2,070 residential homes in Picher, Cardin, Quapaw, Commerce, and North Miami were evaluated. The second five-year review stated that approximately 65% of these properties contained lead above 500 ppm in soil in at least one part of the yard. The Phase II removal response activities were conducted from June 1996 until December 1997. The following criteria were used to prioritize the properties:

- Top priority was given to homes with children less than 6 years of age who had blood lead levels in excess of 10 µg/dl, and where the soil lead concentrations had been determined to be a significant contributor to elevated blood lead levels; and,
- The next highest priority was given to homes where the soil lead concentration exceeded 1,500 ppm (**EPA, 2000b**).

During the Phase I (HAAs) and Phase II (residential properties) removal response actions, remediation was performed at 20 HAAs, one commercial property (used by the EPA, USACE, and their various contractors for on-site support facilities), and 227 residential properties. Approximately 84,417 cubic yards of soil were removed from these properties during the removal actions (E&E, 2000, USACE, 2002, and **Washington Group International, 2002**).

In September 1998, the Quapaw Tribe of Oklahoma requested assistance from the EPA to conduct response activities at an abandoned office complex located in Cardin, Oklahoma. The land was owned by the Quapaw tribe, and had been leased by Eagle-Picher Industries, Inc. from 1945 until 1981. A drum containing residual cyanide had been discovered in one of the site buildings during work conducted in

1998. EPA performed evaluations of the atmosphere inside this building and determined that no cyanide above background levels were present (**EPA, 2000a**).

In March 1999, the Inter-Tribal Environmental Council (ITEC) conducted a site reconnaissance of the property in advance of the completion of an RI/FS being conducted by the ITEC and Quapaw Tribe for the EPA. During this site reconnaissance, 120 containers of laboratory chemicals were discovered at the site. The EPA conducted a Hazardous Characterization, again at the request of the ITEC, in May and June 1999. These chemicals were inventoried, categorized, segregated, and overpacked in preparation of future disposal by the BIA. The BIA informed the EPA that it did not have the funding or expertise to remove the chemicals from the site (**EPA, 2000a**).

On March 2, 2000, an action memorandum was issued by EPA approving a time-critical removal action at the Eagle-Picher Office Complex – Abandoned Mining Chemicals. This portion of the site was designated OU3. The action memorandum determined that the chemicals posed an imminent and substantial endangerment to the public health or welfare or the environment. This determination was made on the basis that the containers in which the chemicals were stored had to be placed outside, where they were exposed to the elements. The EPA was concerned that eventually the containers would deteriorate, releasing the chemicals into the environment (**EPA, 2000a**).

On March 28, 2000, the emergency removal action was conducted. The laboratory chemicals were removed from the site and transported to facilities appropriate for their disposal. The EPA was unable to dispose of some low-level, radioactive uranyl acetate. The EPA remobilized to the site on May 23, 2000. This material was removed from the site and transported to an offsite location for treatment and disposal (**EPA, 2000c**, and **EPA 2000d**). The EPA determined that no further action was required in relation to OU3 (**EPA, 2004a**).

On December 9, 2003, the EPA signed an Administrative Order on Consent (AOC) with three Potentially Responsible Parties (PRPs), including DOI, Blue Tee Corp., and Gold Fields Mining Corporation, to conduct the RI/FS for OU4. Under the terms of the AOC, the EPA prepared the risk assessments for OU4 based on data collected by the PRPs and EPA. A three-phased Site Reconnaissance was conducted from March 29 to April 28, 2005. Field sampling and investigations were conducted in May and concluded in October 2005. The RI/FS reports were issued in July 2007 (**EPA, 2008**).

During the course of the OU4 investigations, EPA performed a pilot project consisting of several field studies regarding injection of chat and fine tailings into flooded mine cavities to determine whether this could be a cost-effective disposal technique. Following the pilot injection, EPA found that the physical placement of chat and fine tailings in flooded mine rooms does initially impact mine water; however, the data indicated that the mine water chemistry rapidly begins to return to pre-placement conditions (**EPA, 2008**). In another pilot under the RI/FS, the United States Department of the Interior (DOI), with the cooperation of the Quapaw Tribe, is promoting responsible chat sales, using Best Management Practices (BMP) to reduce the volume of millions of tons of mining waste. Both pilots, Indian-owned chat sales and the disposal of chat in mine cavities, were response action alternatives considered in the FS (**EPA, 2008**).

Site investigations associated with OU5 are ongoing. Surface water and sediment data have been collected from site streams by EPA, ODEQ, United States Geological Survey (USGS), Cayuga-Seneca Tribe, Quapaw Tribe and other parties. Data evaluation is ongoing. An advanced Screening Level Ecological Risk Assessment (SLERA) is currently being performed under OU5.

3.5 Basis for Taking Action

The purpose of the response actions conducted at the Tar Creek Superfund Site was to protect public health and welfare and the environment from releases or threatened releases of hazardous substances from the site. Discharges of acid mine water from the abandoned mines to surface water and possible direct migration to the underlying Roubidoux aquifer threatened human health and the environment. In addition, exposure to lead contamination in residential soils was determined to be associated with human health risks higher than the acceptable range. The primary threats that the Tar Creek Superfund Site posed to public health and safety were: potential contamination of water supply wells completed in the Roubidoux aquifer from acid mine water; possible direct dermal contact with acid mine water where ground water discharges at the surface; severe ecological impacts to Tar Creek as a result of the acid mine water discharges; oral ingestion of lead contaminated soils; oral ingestion of drinking water; and oral ingestion of chat and tailings material (**EPA, 1984, EPA, 1997, and EPA, 2008**).

4.0 Remedial Actions

This section provides a description of the remedy objectives, remedy selection, and remedy implementation for the three OUs for which RODs have been signed by EPA for the site. It also describes the ongoing Operations and Maintenance (O&M) activities performed at the site in the period since completion of the third five-year review. The three OUs for which RODs have been signed are: (a)

OU1 (surface water/ground water); (b) OU2 (residential properties and HAAs); and (c) OU4 (chat piles, other mine and mill waste, and smelter waste). Two additional OUs have been designated at the site: (a) OU3 (Eagle-Picher Office Complex - abandoned mining chemicals); and (b) OU5 (sediment and surface water). OU3 was addressed through a removal action, and the EPA has determined that no further action is necessary. Investigations related to OU5 are ongoing, and a ROD has not yet been signed.

4.1 Remedial Action Objectives

The specific remedial objectives of the OU1 RA were:

- Mitigate the potential threat to public health and the environment by preventing contamination of the Roubidoux aquifer from acid mine water; and,
- Minimize the damage to Tar Creek from acid mine water discharges (**EPA, 1994a**).

The specific remedial objective of the OU2 RA was:

- Reduce ingestion by humans, especially children, of surface soil in residential areas contaminated with lead at a concentration greater than or equal to 500 ppm (**EPA, 1997**).

The specific remedial objectives of the OU4 RA are:

- Prevent children and adolescents from coming in direct contact, through the ingestion and inhalation exposure pathways, with lead contaminated source material where lead concentrations exceed 500 ppm;
- Prevent terrestrial fauna from coming in direct or indirect contact, through the ingestion exposure pathway, with cadmium-, lead-, or zinc-contaminated source materials and soils where cadmium, lead, and zinc concentrations exceed their respective remediation goals of 10.0 mg/kg, 500 mg/kg, and 1100 mg/kg respectively;
- Prevent riparian biota including waterfowl from coming into contact, through the ingestion exposure pathway, with unacceptable concentrations of cadmium, lead, and zinc in surface water and sediment by eliminating all discharges of cadmium, lead, and zinc from source materials to surface water;
- Prevent children from direct contact, through the ingestion and inhalation exposure, with lead-contaminated soil where soil lead concentrations exceed 500 ppm; and,

- Prevent site residents from the ingestion of water from private wells that contains lead in concentrations exceeding the National Primary Drinking Water Standards (**EPA, 2008**).

4.2 Remedy Selection

Three RODs have been issued by EPA for the Tar Creek Superfund Site. The OU1 ROD addressed the impacts associated with surface water discharges of acid mine water and through the migration of acid mine water from the Boone aquifer to the underlying Roubidoux aquifer. The ROD for OU2 addressed surface soil contamination in residential areas at the site. The OU4 ROD addressed mining waste including chat piles and tailings ponds, smelter wastes, soils contaminated by mining and smelter wastes, a limited number of residential properties with lead-contaminated soils (that were not addressed under OU2), and private residential wells impacted by site related contaminants. The site has also been addressed through other response actions (the two removal response actions for OU2 and the removal action for OU3) as described in [Section 3.4](#).

The ROD for OU1 was signed on June 6, 1984, to address the mitigation of surface water and ground water discharges of acid mine water to Tar Creek and to prevent the potential contamination of the Roubidoux aquifer through acid mine water migration from the overlying Boone aquifer. Elements of OU1 included response actions to address contaminated ground water as a result of acid mine water seepage and contaminated surface water as a result of acid mine water discharges (**EPA, 1984**).

The remedy described in the 1984 ROD for OU1 consisted of the following elements:

- Abandoned wells completed in the Roubidoux aquifer were to be plugged. Each well was to be cleared of obstructions. The wells were then to be plugged from the bottom to the surface using acid resistant cement.
- Surface water diversion and diking structures were to be constructed around two major inflow areas to prevent surface water inflow into the abandoned mines. The two inflow areas were identified as the abandoned mine shafts called Muncie and Big John. These two inflow areas combined were thought to represent 75% of the total surface inflows into the abandoned mines. It was thought that the elimination of these inflow points would cause the ground water levels in the mines to drop and, as a result the amount of acid mine water discharged to the surface would be reduced or eliminated. It was predicted that the Admiralty location would become an inflow point after the initial diking and diversion work was completed, so the ROD allowed for additional diking and surface water diversion around this location if deemed necessary.

- A surface water and ground water monitoring program was to be conducted for two years. The purpose of the monitoring was to assess the effectiveness of the RAs at preventing contamination of the Roubidoux aquifer and reducing the acid mine water discharges into Tar Creek.
- A fund-balancing waiver to certain Applicable or Relevant and Appropriate Requirements (ARARs) was granted. The waiver was invoked in the ROD declaration based on the prohibitively high costs that would be associated with other engineered solutions to address the surface water contamination in Tar Creek. It was determined that these costs would drain the Superfund and put at risk the EPA's ability to address other releases under CERCLA and the NCP (**EPA, 1984**, and **EPA, 2000b**).
- The ROD stated that future RAs would be required if the selected alternatives did not adequately mitigate the risk to human health (**EPA, 1984**).

The ROD for OU2, residential areas, was signed on August 27, 1997. This ROD addressed soils in residential yards and HAAs contaminated with lead (**EPA, 1997**).

The remedy described in the ROD for OU2 (residential areas) included the following elements:

- Excavation of soils in residential areas and HAAs containing lead with concentrations greater than or equal to 500 ppm to a depth of 18 inches. If lead concentrations exceed 500 ppm below 18 inches, a marker consisting of geotextile fabric or other suitable material would be placed in the excavation prior to backfilling to warn of contamination below the barrier. Each excavation was to be backfilled with clean top soil.
- Excavation of obvious hot spots (places where chat contamination was readily observable at the surface).
- Establishing new vegetation using sod or re-seeding.
- Backfilling of traffic areas and driveways with road base materials.
- On site disposal of excavated materials at a permanent long-term disposal area.
- Institutional controls (ICs) which may include the following:
 - 1) Restrictions and management controls on unsafe uses of mine tailings;
 - 2) Restrictions and management controls on activities that would cause recontamination of remediated properties;
 - 3) Restrictions and management controls on activities that would contaminate clean site property with mine tailings;

- 4) Restrictions and management controls intended to prevent future exposure of children to unacceptable levels of lead in the soil at new residential developments that are located in areas with high lead levels in soil;
 - 5) Restrictions and management controls on building and construction activities in order to prevent building and construction practices that would increase exposure to lead-contaminated soils;
 - 6) Restrictions and management controls on access to contaminated property through physical barriers (e. g., fencing) or notices (e. g., warning signs);
 - 7) Public health and environmental ordinances and controls related to lead exposure and management of mine tailings;
 - 8) Placing notices in property deeds regarding contamination;
 - 9) Sampling and analysis of lead sources;
 - 10) Blood lead monitoring;
 - 11) Health education; and,
 - 12) Lead-contaminated dust reduction activities.
- Measures to prevent the recontamination of residential properties, or that would reduce the potential for recontamination of residential properties included:
 - 1) Vegetating poorly vegetated or unvegetated areas;
 - 2) Capping with soil;
 - 3) Capping with base coarse material or paving;
 - 4) Applying dust suppressants or other dust control measures;
 - 5) Controlling drainage;
 - 6) Consolidation of source materials;
 - 7) Containment of source materials; and,
 - 8) Abating lead sources to prevent releases into the environment that would recontaminate remediated areas (**EPA, 1997**).

The OU2 ROD also included several provisions to address lead contaminated soils at the site and within Ottawa County. The ROD expanded the site to include all portions of Ottawa County that were impacted by mining wastes, including HAAs outside the mining area and the entire floodplain of Tar Creek. The ROD contained a provision to cover or replace chat material in alleyways, parking lots, roads, driveways, and other such areas located near residences with road base materials such as gravel or crushed limestone.

The ROD called for expanding the use of physical barriers to restrict access to mining wastes located near residences as deemed appropriate (EPA, 1997).

The ROD for OU2 provided for the establishment of ground cover, such as grass, in bare contaminated soils at certain residences, located generally outside the mining area but within Ottawa County. Finally, the ROD stipulated that, at certain residences located generally outside the mining area but within Ottawa County, where medical monitoring has found that a resident has elevated blood lead levels close to or above 10 µg/dl, and where the residential yard is contaminated with lead at concentrations at or above 500 ppm, the soil would be excavated and replaced as called for under the selected remedy (EPA, 1997).

The ROD for OU4 was signed on February 20, 2008. This ROD addressed source materials, smelter wastes, rural residential yard contamination, transition zone soil contamination, and contamination in water drawn from rural residential wells. The OU4 ROD stated that the remedy would be implemented in two phases over a period of 30 years (EPA, 2008).

The remedy described in the ROD for OU4 included the following elements:

Phase 1:

Phase 1 would address voluntary relocation of residents in the area shown in [Figure 2](#), chat sales, and address source materials in a manner that reduces the overall footprint of contamination and reduces the need for land use restrictions, ICs, and O&M.

- Residents located in Picher, Cardin and Hockerville would be voluntarily relocated following the procedures and priorities established by the Lead Impacted Communities Relocation Assistance Trust (LICRAT).
- Chat and chat bases from distal areas, including associated historic chat covered haul roads and non-operating railroad grades, would be excavated to the underlying native soil, transported and released to an on-site chat processor or future processing location located in a previously contaminated area of the site, injected into the mine workings, or disposed in an on-site repository.
- Transition zone soils (soils around and underneath source materials) would be addressed by excavation followed by natural soil rebuilding.
- Smelter wastes would be excavated and disposed in an on-site repository. Smelter affected soils would be managed in the same manner as transition zone soils.

- Fine tailings would be injected into mine workings or covered in place. The covered fine tailings could be consolidated to reduce the footprint of the final cover.
- Source material in Tar, Lytle, Elm or Beaver Creek or other site waterways, would be addressed on a priority basis through either excavation and/or the installation of a flexible membrane liner, as needed as determined by EPA. As an interim measure, sheet piling, berms, constructed wetlands, or other engineering controls would be installed for near-stream source materials to help prevent contamination from migrating to surface water.
- An alternative water supply would be provided to any household where mining-related contaminants in water drawn from rural residential wells exceeds 0.015 milligrams/liter (mg/L) for lead for rural households. Rural households that were within the area that had been designated for relocation under the LICRAT relocation program, but which did not elect to participate in the relocation program, would be included in the households eligible for an alternative water supply (estimated to be two residences).
- Rural residential yards that were found to have concentrations of soil lead that exceed 500 ppm would be excavated to a maximum depth of 12 inches, and the excavated area would be backfilled with clean soil, contoured to promote drainage, and revegetated. This includes residential yards that were identified for relocation.
- On-site repositories would be constructed to accept site source materials for final disposal. On-site repositories would be closed when they reached capacity or at completion of the RA. Closure would be accomplished by covering the repository with a soil cover, contoured to promote drainage, and revegetated (**EPA, 2008**).

Phase 2:

Phase 2 addresses certain source areas that remain after Phase 1 cleanup activities. These areas may include chat bases, tailings ponds, unmarketable chat piles and bases, and remaining chat from distal area consolidation. Chat sales will continue.

- The remedy would be reviewed, at a minimum, every five years since hazardous substances would remain on-site with concentrations that exceed concentration levels that allow for unrestricted use and unrestricted exposure. The remedy would be reviewed to ensure protection of human health and the environment. As part of the five-year review, EPA would evaluate the progress of chat sales. Chat piles and bases remaining after 10 years would be evaluated for commercial viability. This determination would be made using input from the chat/land owners, appropriate tribal representatives, and the commercial operators.

- Unmarketable chat piles and bases would be excavated, transported and released to an on-site chat processor or future processing location in a previously contaminated area of the site, injected into mine workings, or disposed of in an on-site repository.
- Abandoned chat haul roads and non-operating railroad grades that were contaminated would be managed the same as unmarketable chat piles and bases.
- ICs and O&M activities would be implemented, as needed as determined by EPA, at repositories and covered, fine tailings ponds.
- Environmental monitoring would be conducted, as needed as determined by EPA, to test for contamination in ambient and near source air, surface water, ground water, and sediment during remediation activities.

Other actions included in the selected remedy for OU4 are discussed below.

Chat sales were selected as part of the CERCLA remedy. The OU4 ROD states that although EPA does not own and will not purchase chat, it will assist chat sales participants. The responsible sale of chat under the Chat Rule, 40 CFR Part 278, will decrease the amount of chat on site in a way that brings added benefits to the community while reducing exposure risks.

As part of the OU4 ROD, a watershed-based approach is being taken, including development of a baseline hydrology model to reflect the existing land uses in the basin and reflect any rainfall storage within the source materials. Runoff is expected to increase as the capacity of the soil to absorb rainfall on-site decreases, and the model may be used in the future to manage increased runoff and stream flow.

Under the selected remedy, ICs include deed notices placed on land parcels that are contained in the site. Such ICs would notify current and potential future deed holders of the presence of wastes left on-site. The IC instrument to restrict land use is a Deed Notice and Easement filed pursuant to Oklahoma Statute 27A § 2-7-123(B). An additional IC is to be implemented to restrict use of ground water from the Boone aquifer (or shallower) for potable or domestic supply when that water source is impacted with site-related contaminants above the final remediation goals. The IC instrument in this case is to be implemented through the Oklahoma Water Quality Standards (OWQS) Title 785, Chapter 45, Appendix H (**EPA, 2008**). Appendix H currently states that toxic metals are present and that special well construction methods are required within the OU4 boundary due to contamination in the Boone aquifer, but there are currently no limitations placed on the use of ground water from the Boone aquifer for potable and domestic supply.

To ensure that injection of chat complies with Underground Injection Control (UIC) regulations for a mine backfill well, a site-wide hydrogeologic study would be performed. The study will address the requirements of the regulations and will examine whether there is hydraulic connectivity between the Picher Field and the Commerce mine working, identify strategic subsurface locations for injection in order to maximize the number of potential injection sites needed to adequately alter the hydrogeology, and evaluate the long-term effectiveness of this method (**EPA, 2008**).

As part of addressing in-stream source materials, removed source materials will be returned to the nearby chat piles, chat bases, or tailings ponds from which it appears that they came, as determined by EPA, prior to remediation of such chat piles, bases or tailings ponds. When in-stream chat outside of the distal area is returned to its point of origin, the owners of the chat may sell it or dispose of it as is outlined in the OU4 ROD (**EPA, 2008**).

In April 2010, EPA signed an ESD to the OU4 ROD. The ESD explains that, consistent with the OU4 ROD, EPA has decided to complete a voluntary relocation of residents in Treece, Kansas as part of the OU4 remedial action (RA) (**EPA, 2010b**).

4.3 Remedy Implementation

After signing the ROD for OU1, the surface water diversion and diking work at the Big John and Muncie Mine sites proceeded as part of the RA. It was also decided to proceed with the diking and diversion work at the Admiralty Mine site. The construction at these three sites was completed on December 22, 1986 (**EPA, 1994**).

The work to clear and plug the 66 abandoned Roubidoux wells identified in the ROD began in September 1985, when IT Corporation was contracted by the OWRB to conduct the work. Of the 66 identified wells, 4 wells could not be located, 7 wells were found to be shallow (not completed in the Roubidoux aquifer), 3 wells were still in use, 2 wells had been properly plugged and abandoned, and access was not granted at one well location. In addition, 2 wells were not plugged due to high cost, and at 4 of the wells, it was not physically feasible to plug the entire well, so a cement plug was placed at the floor of the mine workings. The remaining 43 wells were properly plugged and abandoned (**IT, 1985**). After completion of the initial work, 17 additional wells were identified. The OWRB contracted with Engineering Enterprises, Inc. to conduct the additional work. Of the 17 wells, 13 were plugged and abandoned. Two wells were determined to be shallow vent holes or dewatering wells, and were not plugged. Two wells

were not plugged due to technical difficulties. The additional work was completed in October 1986 (**EEL, 1986**).

Following construction activities at OU1, a two-year monitoring and surveillance program was conducted to assess the effectiveness of the RA activities at mitigating the acid mine drainage discharges to Tar Creek and preventing the migration of the acid mine water to the Roubidoux aquifer. Surface water flow measurements and water quality data were collected at locations along and near Tar Creek to determine if the pollutant loading to Tar Creek had changed as a result of the RA construction activities. Water levels were monitored in the Blue Goose Mine (considered to be indicative of the water levels within the Boone aquifer and related to the discharge volumes from the mines to Tar Creek) to determine if the water levels within the Boone aquifer and the mine workings had decreased. Finally, water quality data were collected from public water supply wells completed within the Roubidoux aquifer to assess the water quality after completion of the well plugging activities. These monitoring activities were conducted in 1987 and 1988. The results of the monitoring and surveillance program were detailed in a report submitted by the OWRB to the EPA in 1991 and summarized in the first Five-Year Review Report (**EPA, 1994a**). Further discussion regarding the results of this monitoring are provided in [Section 4.5](#).

After signing the ROD for OU2, the removal actions being conducted for the HAAs and residential properties were transitioned into the RA for OU2. The EPA and the USACE signed an IAG in September 1999. The USACE conducted the Remedial Design (RD)/RA under the direction of the EPA. MK was the contractor selected by the USACE to perform the RD/RA for OU2 (**USACE, 2002**).

MK began remediation at the site in February 1998. During assessment activities conducted between 1996 and 2000, approximately 2,774 properties were identified that required assessment sampling for lead in soils. Of these properties, 2,380 were assessed for lead contamination, and 2,106 exceeded the 500 ppm remediation goal for lead (88% of the assessed properties) (**Washington Group International, 2002**). The USACE and MK conducted remediation at 1,300 properties during the RA. These 1,300 properties were the original properties identified by the OU2 ROD as requiring remediation. The USACE and MK completed the RA for the 1,300 properties identified at the time the OU2 ROD was signed in July 2000. MK and the USACE demobilized from the site in September, 2000 (**USACE, 2002**). After July 2000, the EPA contracted directly with CH2M HILL, Inc. to complete the RA for the remaining 565 properties still to be addressed at the site. A total of 649 properties were remediated by CH2M HILL. The remediation efforts at these properties were conducted from September 2000 to March 2006. This number includes 140 properties administered by the BIA, 495 additional residential

properties, and 14 additional HAAs (7 schools located in Miami, one school located in Picher, 1 school playground located in Picher, 4 daycare facilities located in Miami, and the Mutt Mantle Ball Field in Ottawa County) (CH2M HILL, 2007a). During the various sampling efforts conducted during this period, properties were determined to be contaminated but the cities elected to perform the remediation work. The City of Afton elected to remediate the Afton Little League Ball Park, and the City of Fairland elected to remediate the Fairland Little League Ball Parks. The remediation was accomplished by providing pavement over each of the identified contaminated areas. The City of Miami was in the process of remediating multiple park properties under an agreement with ODEQ at the time the Remedial Action Report (RAR) was being written. In 2005, the City of Commerce, under an agreement with ODEQ, began implementing the remediation of the 98 remaining properties that were located within their city limits. Through January 2010, more than 2,295 residential properties and HAAs have been remediated as part of either the removal response actions or the OU2 RA (EPA, 2010a).

Currently, the RD and RA for OU4 are being developed and implemented. The voluntary relocation, which was occurring at the time the ROD was signed, has proceeded and is anticipated to be completed in 2010. The hydrogeologic characterization study, which will determine whether the injection component of the selected remedy will comply with the UIC regulations, began in 2008 and will be completed in 2010. The RD for rural residential properties, smelter wastes, distal area chat, in-stream chat in Tar Creek, and the Phase 1 of the repository began in 2009. RA activities associated with these RDs began in late 2009.

4.4 Operations and Maintenance and Long-Term Monitoring

The State of Oklahoma, through the OWRB and, since 1993, the ODEQ (the ODEQ was formed in 1993 and took over Superfund responsibilities in the State of Oklahoma from the ODSH and OWRB at that time), is responsible for conducting the Roubidoux Ground Water Monitoring Program (also referred to in site documents as the Long-Term Monitoring [LTM] Program or After Action Monitoring [AAM] Program) activities, well plugging activities, and O&M for OU1. These activities are conducted through a Cooperative Agreement between the ODEQ and EPA.

The ROD for OU1 does not specifically state what O&M activities were to occur at the site. However, the ROD does mention O&M and costs related to the dikes and diversion work. The ROD also stipulated that a two-year monitoring and surveillance program would be conducted after construction of the selected remedies to assess the effectiveness of the RA at mitigating the acid mine discharges to Tar Creek and preventing the migration of the acid mine water to the Roubidoux aquifer (EPA, 1984). The

results of the two-year monitoring and surveillance program were summarized and presented in the first five-year review report. After completion of the two-year monitoring program, it was determined that the Roubidoux Ground Water Monitoring Program would continue for OU1 to further investigate potential impacts to the Roubidoux aquifer from acid mine water. The First Five-Year Review Report stated that after completion of this program, monitoring of the water quality in the Roubidoux aquifer would be accomplished through the normal sampling conducted by the various water supply operators as required by the Safe Drinking Water Act (SDWA) (EPA, 1994a). The Roubidoux Ground Water Monitoring Program was conducted in two phases. Phase I activities were presented in the Second Five-Year Review Report (EPA, 2000b). The results of Phase II were presented in the Third Five-Year Review (EPA, 2005).

After completion of the Phase II Roubidoux Ground Water Monitoring Program, the ODEQ implemented a follow-up ground water monitoring program with the approval of the EPA. The ODEQ determined that the monitoring conducted by local water supply operators was inadequate for purposes of monitoring the water quality in the Roubidoux aquifer. The ODEQ's reasons for this conclusion were: the analytical parameters and frequency of sampling vary between individual water suppliers; the sampling procedures are not consistent between water suppliers; and the sampling is conducted without an approved Quality Assurance Project Plan (QAPP). The ODEQ therefore recommended the ground water monitoring program to provide consistent analytical testing procedures and sampling schedules and to ensure the quality and consistency of the data (ODEQ, 2002b).

Beginning in November 2003, the Roubidoux Ground Water Monitoring Sampling Program involved the sampling of 14 wells located at or near the site. These wells included 3 monitoring wells installed by the ODEQ, 10 municipal supply wells, and one private well. Each well was sampled twice a year for 5 years. During implementation, several changes were made to the sampling program. Well Miami #1 became inoperable before the October 2004 sampling event and was replaced by Miami #3. Wells Miami #11 and RWD7 #2 were added as background wells in November 2006, the first because of its location between the mine area and Miami, and the second because of its westerly location (ODEQ, 2009a). This phase of sampling under the Roubidoux Ground Water Monitoring Program concluded in April 2008 (ODEQ, 2008b). The results of the sampling program are discussed in [Section 6.4](#). It should be noted that neither the EPA nor ODEQ have identified any public drinking water wells at the site that fail to meet the Maximum Contaminant Levels (MCLs) established under the SDWA. That is, the drinking water at the site is safe for all uses.

The ROD for OU1 recognized that additional abandoned Roubidoux wells might be identified in the future. The ROD contained provisions to evaluate the need and to plug additional wells if warranted (**EPA, 1984**). The ODEQ has identified 19 wells that require further assessment (**ODEQ, 2006c**). The EPA and ODEQ continue to evaluate the need to plug abandoned Roubidoux wells when wells are identified and located.

The dikes and stream channel diversion work completed at the Muncie, Big John, and Admiralty sites were inspected as part of the site inspection for this five-year review.

The OU2 ROD selected remedy call for excavated contaminated soil to be disposed of at an on-site repository. Once EPA finished using the repository, the area is to be vegetated with grass to help control erosion by wind or water. The repository would be capped with clean soil prior to vegetating, unless the surface of the disposal area already has soil lead concentrations less than 500 ppm. ICs would be placed on the repository and may include instituting management controls on new residential developments and buildings and construction activities to prevent exposure of children to unacceptable levels of lead in the soil, and placing notices in property deeds regarding contamination. The OU2 ROD specifies O&M for OU2 to maintain the caps placed on the repositories used to dispose of excavated soils once the RA construction activities are completed (**EPA, 1997**). The repositories used during the course of the RA were expected to be put to use as pasture land for grazing rather than closed out as landfills. The North Repository, used and operated by previous contractors at the site, was closed by CH2M HILL (**CH2M HILL, 2007a**). At the request of EPA, CH2M HILL installed a fence and gates to prevent unauthorized access onto the County Repository, which will be used by Ottawa County employees and local residents to deposit impacted soil from county road maintenance and excavation for local utility work (**CH2M HILL, 2007b**). The South Repository was closed in 2006 through a process of final site grading, leveling, removal of bulk debris, and vegetative cover establishment. After the work was completed, the property owner expressed concern that the vegetative cover was not well established. A plan of action to address the concerns has been identified and is expected to be executed in Spring 2010 (**CH2M HILL, 2009**).

The EPA determined that no further action was warranted to address OU3, and O&M activities are not required for OU3 (**EPA, 2000a**). The RD and RA are currently being conducted for OU4 and no O&M activities are occurring.

4.5 Progress Since Initiation of Remedial Action

As discussed in [Section 4.3](#), a two-year monitoring and surveillance program was conducted for the OU1 remedy during 1987 and 1988 by the OWRB. The data obtained from these activities were reviewed by the EPA's Robert S. Kerr Environmental Research Laboratory (RSKERL). RSKERL submitted a report in September 1989 (RSKERL, 1989). The OWRB documented the results and findings, including a summary of the conclusions of the RSKERL review, in a report submitted to the EPA in April 1991 (OWRB, 1991). The OWRB provided the following conclusions, which were summarized in the first five-year review report:

- The volume of the acid mine water discharged to Tar Creek was not significantly impacted by the OU1 RA;
- The concentrations of most constituents in the acid mine water discharges were decreasing. The cause of the decreasing concentrations was not known, but the OWRB stated the decreases were most likely the result of natural processes;
- The surface water quality was not significantly improved in Tar Creek, and the diking and diversion work was at best only partially effective; and,
- Although some public water supply wells in the Roubidoux aquifer were affected by acid mine water, insufficient data existed to evaluate the effectiveness of the well plugging activities. Neither EPA nor ODEQ identified any public drinking water wells at the site that failed to meet the MCLs established under the SDWA, and the drinking water at the site was determined to be safe for all uses.

The EPA concurred with these findings (EPA, 1994a).

The EPA provided further findings and conclusions based on the data in the first five-year review report. These findings and conclusions included the following:

- The surface water data collected from Tar Creek were insufficient to perform statistical analysis due to the short monitoring period following construction;
- Monitoring data from the acid mine water discharges indicated that the contaminant concentrations were decreasing;
- The data indicated that the pollutant loading in Tar Creek was decreasing. The OWRB calculated that only 15% of the total metals loading to Tar Creek was from identified major discharges;

- The sediment data were erratic and conclusions on the effectiveness of the remediation could not be drawn; and,
- The data from the monitoring of water levels in the Blue Goose mine showed that overall, the long term average water level in the Boone aquifer had not been reduced. However, the diking and diversion work had reduced short-term rises in water levels in the mines in response to precipitation events (**EPA, 1994a**).

The EPA's overall conclusion in the first five-year review was that other sources of recharge were contributing more to the acid mine water discharges to Tar Creek than previously estimated. The EPA concluded that the diking and diversion structures were effective at reducing surface water inflows into the mines in relation to specific precipitation events. However, the diking and diversion structures were at best only partially effective at achieving the remedial goal of decreasing the acid mine water discharges to Tar Creek (**EPA, 1994a**).

The first five-year review report recommended that the post remediation ground water monitoring program be extended to evaluate the success of the well plugging program at preventing contamination of the Roubidoux aquifer (this program was already in progress). Also, 15 additional abandoned wells were identified after completion of the second well plugging program. The EPA recommended evaluating the need to plug these wells based on the results of the post remediation ground water monitoring program. Due to changes in the designated uses for Tar Creek, as stated in the OWQS (see discussion under [Section 7.1](#)), the EPA recommended no further RA or monitoring of Tar Creek. The other recommendations of the First Five-Year Review, related to OU2, are discussed in [Section 3.4](#) (**EPA, 1994a**).

The Phase I Roubidoux Ground Water Monitoring Program was begun in 1991 to determine the quality of the water in the Roubidoux aquifer and to assess the effectiveness of the well plugging activities. The goal of the program was to determine if acid mine water had contaminated the public water supply obtained from the Roubidoux aquifer. The program included wellhead sampling of municipal supply wells and discrete sampling of the Roubidoux aquifer. The wellhead sampling program was performed by the USGS for the OWRB between August 1992 and January 1993. Ten wells inside the mining area and one well outside the mining area (used to determine background concentrations) were sampled monthly during this period (**EPA, 1994a**). The OU1 ROD did not set criteria to act as a "trigger" for action or decision regarding the effectiveness of the well plugging program. To provide such a trigger, in January 1993, an additional 10 wells outside the mining area were also sampled. By using wells outside

the mining area, more statistically reliable data on background conditions could be gathered and indicator parameters that could be used to indicate the presence of acid mine water influx could be determined. Zinc, iron, and sulfate were chosen as indicator constituents of acid mine water influx due to large concentration differences for these constituents when comparing acid mine water to the background Roubidoux aquifer concentrations (EPA, 1994a). In addition to calculating background concentrations for the indicator parameters, the ODEQ established tolerance limits (statistically derived values representative of the upper limit of background concentrations) for each parameter (ODEQ, 1993). The background concentrations and tolerance limits for these indicator parameters are provided in [Table 2](#).

The results of the wellhead sampling were documented in an ODEQ report submitted in July 1993. The data showed that all 21 wells sampled were meeting the primary drinking water standards (primary drinking water standards are enforceable, health-based contaminant concentration limits established by EPA). However, five of the wells failed the secondary drinking water standards (secondary drinking water standards are non-enforceable standards established by EPA for aesthetic purposes such as taste or odor) for iron, and one of those wells also failed the secondary drinking water standard for sulfate. Three of the five wells were located in Picher, one well was located in Commerce, and one well was located in Quapaw. The EPA determined that these five wells were impacted by acid mine water from the Boone aquifer, but it was not demonstrated if the impact was related to widespread infiltration of acid mine water into the Roubidoux from the Boone aquifer or due to well integrity problems (ODEQ, 1993, and EPA, 1994a).

Discrete sampling of the Roubidoux aquifer was conducted by the ODEQ from 1996 until 2002. The ODEQ obtained samples from the impacted drinking water supply wells in Picher, Commerce, and Quapaw. After completion of Phase II, the ODEQ implemented continued monitoring in November 2003 as described in [Section 4.4](#). The results of the sampling program are discussed in [Section 6.4](#).

The EPA performed statistical trend evaluations for the data collected between 2003 and 2006. The results of this evaluation are discussed in [Section 6.4](#).

More than 2,295 residential properties and HAAs have been remediated as part of the removal response actions and OU2 RA. Over 512,000 cubic yards of lead contaminated soils have been removed as part of these efforts and placed in two on-site repositories. The RA activities for OU2 are still ongoing. The EPA is currently performing reconnaissance efforts to evaluate the presence of chat in alleyways and drive ways in the remainder of Ottawa County. EPA is also planning efforts to assess and remediate

where necessary the footprints of houses removed under the voluntary relocation being performed as part of OU4 (**EPA, 2005, EPA, 2010a, and CH2M HILL, 2007b**).

The most recent study published on blood-lead levels in children was by the U. S. Agency for Toxic Substances and Disease Registry (ATSDR) in 2004 (and discussed in the third five-year review report). The report stated that the percentage of children between the ages of 1 and 5 at the site with elevated blood lead levels had decreased between 1995 and 2003. The report stated that 2.8 percent of the children tested had elevated blood lead levels (above 10 µg/dl), which was only slightly higher than the percentage of children in the United States as a whole (2.2 percent). The ATSDR further concluded that the available evidence indicated that mine tailings in residential soils was the primary exposure pathway and source of lead in children's blood at the site prior to the EPA's implementation of the OU2 RA, but other potential exposure pathways needed further investigation (**ATSDR 2004a, and EPA, 2010a**). The EPA continues to fund the ATSDR and the Ottawa County Health Department (OCHD) to perform community education efforts and blood lead screening at the site. The OCHD also provides education to the local medical community (**EPA, 2010a**).

As a follow-up to the 2004 survey, ATSDR and OSDH reviewed disease rates and other health information about the Ottawa County community focusing on children's health, cancer, and other health conditions in Ottawa County. ATSDR and OSDH found that Ottawa County residents have a health status similar to that of other Oklahoma residents. Currently, only about 3% of preschool children in Ottawa County have elevated blood lead levels, slightly higher than state and national rates. The OCHD is pursuing an extensive, ongoing program that provides free blood lead screening services to children and pregnant women in the county (**ATSDR, 2008**).

The OU4 RI/FS and BHHRA are complete. The RI was completed in December 2005, and the FS was completed in July 2007. The RI was completed December 2005, and the FS was made available to the public in July 2007 (**AATA, 2005 and CH2M HILL, 2007c**). In lieu of conducting a Baseline Ecological Risk Assessment (ERA) for OU4, the Ecological Remediation Goals developed by EPA for the Cherokee County Superfund Site (located across the state line in Kansas) were considered because of numerous similarities between the two sites including location, ecological sub region and province (Osage Plains section of the Central Lowland Province), and similar concentrations of lead, cadmium, and zinc. Other similarities between the sites including climate, topography, flora and fauna, made the determination to use the Cherokee County site ERA appropriate for OU4 (**EPA, 2008**).

The voluntary relocation performed by LICRAT began in 2006. The program was originally implemented to allow residents to relocate due to concerns associated with subsidence issues (**OK, 2006**). During the Proposed Plan and comment period for the OU4 ROD, local citizens expressed a preference for inclusion of relocation as part of the OU4 remedy. The EPA concurred and included funding for the LICRAT as part of the selected remedy in the OU4 ROD (**EPA, 2008**). The EPA is only providing funding to LICRAT as part of the OU4 remedy. The LICRAT plans to complete the voluntary relocation program in 2010.

EPA has begun implementation of portions of the RD and RA for OU4. The hydrogeological characterization study, specified in the OU4 ROD to assess whether or not the injection component of the remedy will comply with UIC regulations, began in 2008 and will be completed in 2010. A pilot study involving the injection of washed fine tailings from a commercial chat washing plant is being performed as part of this study (see [Attachment 4 – Photographs 70 – 77](#)).

4.6 Activities Conducted at the Site by Other Governmental Agencies Since the Third Five-Year Review

Various other Federal, Tribal, State, and local agencies are also performing work at the Tar Creek Superfund Site to address various environmental, health, and safety risks associated with the site. On May 1, 2003, the EPA, United States Department of the Army (through the USACE), and the DOI entered into a Memorandum of Understanding (MOU) for the Tar Creek Superfund Site. The purpose of the MOU is to facilitate cooperation between each signatory and provide for coordinated response, reclamation, and restoration activities under the statutory authorities of each signatory to the MOU. Due to the complexity, size, and scope of the issues at the Tar Creek Superfund Site, the MOU states that the signatory Agencies will work together to coordinate activities with the State, Tribes, local governments, and local community groups to develop and implement solutions that address the health, safety, and environmental issues at the Tar Creek Superfund Site. The MOU called for the creation of a Federal Tar Creek Steering Committee to work with the Tribal, State, and local governments towards these goals (**EPA, USA, and DOI, 2003**). Various Federal, State, and local governmental agencies and local community groups are conducting multiple meetings in order to share information and keep parties informed regarding the work and various studies that are being pursued in and around the site (**USACE, 2004a, and EPA, 2010a**). The following paragraphs describe the activities these various agencies are conducting, outside of the EPA's Superfund work, at the Tar Creek Superfund Site.

The University of Oklahoma has constructed and is currently operating a passive treatment system (constructed wetland) to treat acid mine discharges in the Commerce area and to improve surface water quality in Tar Creek downstream of the treatment system (See [Attachment 4 – Photographs 78 – 85](#)). This project is being conducted as a pilot study under the Oklahoma Plan for Tar Creek (**ODEQ, the Quapaw Tribe, University of Oklahoma, and Senator James Inhofe, undated**) to determine the feasibility of passive treatment of the acid mine discharges through the use of constructed wetlands.

The State of Oklahoma, through the Oklahoma Conservation Commission (OCC), completed a pilot study project in late 2006 and early 2007. The pilot study was a land reclamation project that involved the removal of chat from the land surface. The chat was injected into the mine workings at the Southern Queen mine on the west side of Commerce. Approximately 10,000 cubic yards of chat were injected into the mine workings under this project. The ODEQ continues to monitor the ground water at this site (**CH2M HILL, 2010a**).

In a follow-up to the fish consumption study completed in 2003, the ODEQ conducted a second fish consumption study in 2007. The ODEQ collected and analyzed fish from the Neosho and Spring Rivers, Grand Lake, and local ponds in Ottawa County receiving mine waste runoff. In response to the recommendations of the original study, analytical reporting limits for the 2007 study were lowered from 0.3 milligrams per kilogram (mg/kg) to 0.05 mg/kg for cadmium, from 0.25 mg/kg to 0.05 mg/kg for lead, and from 0.3 mg/kg to 0.1 mg/kg for zinc. The research also studied fish collected from downstream locations along Grand Lake and the Neosho River below the dam of Grand Lake as recommended by the original report. It concluded that the consumption of some preparations of fish caught in waters affected by contaminated runoff from abandoned lead and zinc mines in the Oklahoma portion of the Tri-State Mining District have levels of lead that could potentially cause adverse health effects. Separate advisory levels were determined for both residents living within and those living outside of the Tar Creek area using different background exposure assumptions (**ODEQ, 2007a**). Results were compiled into a revised fish consumption advisory, released August 5, 2008. The advisory breaks out fish consumption suggestions on an easy-to-read chart for residents and non-residents of Tar Creek based on type of fish and based on the location from which the fish was caught ([Figure 3](#)) (**ODEQ, 2008c**).

The USGS is currently working on several projects at the site. The USGS, in partnership with the ODEQ and the Quapaw and Seneca-Cayuga Tribes, has performed stream and sediment sampling along Tar Creek, the Spring River, the Neosho River, and Upper Grand Lake. Aluminum and iron concentrations of several thousand mg/kg, along with elevated manganese, zinc, lead and cadmium concentrations, were measured in sediments collected from the upstream end of Grand Lake O' the Cherokees. In 2004,

sediment cores collected in a transect across the floodplain of Tar Creek near Miami, Oklahoma resulted in similar or greater concentrations of these metals. The greatest concentrations of cadmium, iron, lead, and zinc were detected in sediments beneath an intermittent tributary to Tar Creek, a slough which drains mined areas near Commerce, Oklahoma. In surface water, aluminum and iron concentrations were greatest in the Neosho River. The greatest concentrations of cadmium, lead, manganese, and zinc were measured in surface water from Tar Creek (**USGS, 2009**).

Mine subsidence was not systematically addressed as part of the environmental restoration activities and was identified by the Tar Creek Task Force as a major concern. The USACE was designated to be the lead agency on the subsidence evaluation project and a technical team was assembled in August 2004 to begin the subsidence evaluation. The subsidence study focused on the residential areas of Picher, Cardin, Hockerville, and Quapaw and transportation corridors of major significance in the Picher Mining Field. Major conclusions of the study included that the potential for shaft related and non shaft related subsidence is a very serious threat to the safety and economic well-being of people who reside in and travel through the area. Some residential and public-use areas and portions of transportation corridors are subject to some degree of subsidence hazard. The magnitude of possible subsidence at locations evaluated in the study ranged from less than 1 foot to greater than 50 feet with the attendant possibility of loss of life and/or property depending upon where the subsidence occurs. A summary in the report included site-specific recommendation for public use areas, residential/commercial areas, major transportation corridors, residential streets and rural, agricultural and undeveloped areas (**Subsidence Evaluation Team, 2006**).

The U.S. Fish and Wildlife Service will be conducting the 2009 TSMD Transition Zone Assessment Study, intended to provide the information needed to determine the extent of soil degradation from historic mining operations in the TSMD. Sampling and analysis will be completed in November/December 2009 to assess soil quality conditions in the Transition Zones of the TSMD (**FWS, 2009**).

5.0 Progress Since the Third Five-Year Review

The third five-year review of the site was completed in September 2005, for the period from April 2000, when the second five-year review was completed, through September 2005. The findings of the third five-year review, the status of recommendations and follow-up actions, the results of implemented actions, and the status of any other issues are described in the following sections.

5.1 Protectiveness Statements from Third Five-Year Review

The third five-year review report concluded that the RAs implemented at the site were protective of human health and the environment. The third five-year review report stated that for OU1, the Roubidoux aquifer continued to meet all health-based primary drinking water standards. In addition, the report stated that, although environmental components of the OWQS were not being met for Tar Creek, there was no indication that a threat to human health exists. The OU1 ROD invoked a fund-balancing waiver for the ARARs regarding the environmental risks related to surface water. The third five-year review determined that the conditions regarding this waiver had not substantially changed, and the waiver was still appropriate for the site. The State-designated use of Tar Creek surface water did not pose a risk to human health. Human health was protected by the remedy implemented for OU1. The EPA continues to find that, due to the potential drain on the Superfund and due to the impact that drain would have on the EPA's ability to address other releases under CERCLA and the NCP, it is not appropriate to address environmental risks for surface water in Tar Creek (**EPA, 2005**).

For OU2, the Third Five-Year Review Report stated that the OU2 remedy being implemented was protective of human health and the environment in the remediated areas. At that time 2,072 properties had been remediated, and others were still to be identified and remediated (**EPA, 2005**).

The Third Five-Year Review Report stated that the action implemented during the Removal Action for OU3 was shown to be protective of human health and the environment. The laboratory chemicals left at the former Eagle-Picher Office Complex were removed from the site and properly disposed of (**EPA, 2005**).

The RI/FS, BHHRA, and ERA for OU4 were being conducted at the time of the third five-year review report. With the exceptions noted above, the third five-year review report stated that the environmental components of the OWQS for OU1, the completed RAs, Roubidoux Ground Water Monitoring Program, and O&M activities for the Tar Creek Superfund Site were all protective for the short term. The overall remedy for the site was shown to be protective of human health and the environment for the short term and would continue to be protective if action items in the report were addressed (**EPA, 2005**).

5.2 Third Five-Year Review Recommendations and Follow-up Actions

The third five-year review of the Tar Creek Superfund Site, completed in September 2005, recommended the following follow-up actions:

- **Develop an O&M Plan for the dikes and diversion channels.** The ODEQ has indicated that at the time of the third five-year review report, the last O&M Plan developed for the diversion dike and channel at the Admiralty Mine Site was prepared in 1987. It was recommended that the O&M Plan prepared for the Admiralty Mine Site should be updated. The ODEQ also indicated as part of the third five-year review report that the 20-year property easement for the dike and diversion channel at the Admiralty Mine Site should be extended and updated.

Regarding the Muncie and Big John Mine Sites, the EPA would continue to inspect the dikes and diversion channel at the Muncie and Big John Mine Sites as part of each five-year review. Any necessary maintenance identified during each inspection would be reported to the State of Kansas for appropriate action.

- **Collect and evaluate current and recent surface water and soil/sediment data to verify that no threat to human health exists in Tar Creek.** The second five-year review recommended that the EPA review the need for updated monitoring of the contamination in Tar Creek to evaluate human health impacts. The EPA has conducted soil sampling along the flood plain of Tar Creek to determine lead concentration trends within the flood plain. The ODEQ and USGS were currently conducting sampling of the sediments and surface water quality in Tar Creek at the time of the third five-year review report. If these data were found to be appropriate for the purpose of evaluating human health impacts, these data should be used for that purpose. If necessary, it was also recommended that the EPA should collect enough additional data to determine if potential human health risks are posed by the surface water and sediments in Tar Creek. If it was determined that Tar Creek potentially poses a human health risk, then it was recommended that the EPA evaluate the need to conduct a BHHRA to quantify the risks.
- **Complete the additional fish tissues studies as recommended by the ODEQ's 2003 report.** In As discussed in Section 4.6, in July 2003 the ODEQ completed fish tissue studies based on samples collected in several ponds at the site as well as the Neosho and Spring rivers. The study resulted in the conclusion that skinless fish fillets were safe limited for consumption, but whole-eviscerated and whole un-eviscerated fish were determined to not be safe for consumption. The ODEQ issued a fish consumption advisory for the Tar Creek Superfund Site and the Neosho and Grand Rivers based on the findings of this study (ODEQ, 2003c). Previous determinations that fish at the site were safe for consumption were based on older data. The ODEQ's 2003 fish tissue sampling report recommended that additional studies be conducted, equipment with lower detection limits, to verify the results of the

first study and to determine the downstream extent of the metals uptake in fish. It was recommended by the third five-year review report that the ODEQ to complete the additional recommended study to determine if extension of the fish consumption advisory to areas further downstream was necessary. The ODEQ is pursuing plans to initiate the additional fish studies.

- **Continue with the follow-up Roubidoux Ground Water Monitoring Program (formerly LTM) program and background reassessment for the Roubidoux aquifer.** It was recommended by the third five-year review report that the follow-up Roubidoux Ground Water Monitoring Program continue so that the effectiveness of the well plugging program could be determined. As part of the monitoring program, it was is further recommended that the Roubidoux background reassessment proposed by the ODEQ be conducted to verify that the indicator parameters, background concentrations, and tolerance limits used as triggers to indicate acid mine water influx from the Boone aquifer to the Roubidoux aquifer are appropriate. If it was determined through the monitoring program that the acid mine water influx represents a more widespread regional problem, it was recommended that the need for additional activities (such as continued or more widespread monitoring) will be evaluated. If it was determined through the monitoring program that the Roubidoux aquifer is no longer capable of meeting the primary drinking water standards, it was recommended that the need for additional RAs will be reevaluated. It was should be noted at the time of the third five-year review report that neither the EPA nor ODEQ had identified any wells at the site that failed to meet the MCLs established under the SDWA and that. That is, the drinking water at the site was determined to be is safe for all uses.
- **Continue plugging abandoned Roubidoux wells.** The OU1 ROD provided for plugging additional abandoned Roubidoux wells as they are identified at the site. It was recommended by the third five-year review report that these efforts should continue in order to prevent contamination from migrating from the Boone aquifer into the Roubidoux aquifer. It was recommended that, as additional abandoned wells were identified, efforts should be undertaken to locate each the well, determine that the well is completed in the Roubidoux aquifer, and plug those abandoned wells completed in the Roubidoux aquifer where deemed technically feasible.
- **Continue with the OU2 RA.** The third five-year review report recommended that residential yard and HAA remediation as stated in the OU2 ROD should continue. The residential yard remediation was underway at the time of the third five-year review report.

- **Conduct the RI/FS, BHHRA, and ERA for OU4.** The Third Five-Year Review Report recommended that efforts to complete the RI/FS, BHHRA, and ERA to address the remaining mining wastes at the site for OU4 should continue (**EPA, 2005**).

5.3 Status of Recommended Actions

The current status of implementation of the recommendations included in the third five-year review report is summarized in [Table 3](#).

The third five-year review report recommended development of an O&M Plan for the dike and diversion channel at the Admiralty site by ODEQ. This action has not been implemented and remains an issue for this five-year review. The EPA visited the Muncie and Big John sites during the site inspection performed as part of this five-year review (see [Section 6.6](#)).

The third five-year review report recommended that current and recent surface water and soil/sediment data be collected and evaluated to verify that no threat to human health exists in Tar Creek. EPA Region 6 is working with EPA Region 7 as part of a multi-state effort to characterize sediment and surface water throughout the Spring and Neosho River basins. Sampling was conducted in May 2006 during the summer of 2007. This sampling focused on collecting data to evaluate the toxicity of the sediments (**EPA, 2010a**). A study conducted by the USGS and the ODEQ in cooperation with EPA and the Quapaw and Seneca-Cayuga Tribes of Oklahoma summarized concentrations and loads of selected metals in samples of lakebed sediments, floodplain sediments, streambed sediment and surface water samples collected from 2000 through 2006 at 30 sites in the mining district (**Andrews, 2009**). EPA is currently conducting a study that includes collecting surface water and sediment data along Tar Creek, Lytle Creek, Elm Creek and Beaver Creek. An evaluation of the data collected from these various studies relative to potential threats to human health has not yet been performed.

The third five-year review report recommended that the additional fish tissues studies be conducted as recommended by the ODEQ's 2003 report. The ODEQ conducted a follow-up study in 2007 as described in [Section 4.6](#), and the fish consumption advisory was revised in August 2008.

The third five-year review report recommended a continuation of the Roubidoux Ground Water Monitoring Program for the Roubidoux aquifer to evaluate whether the well plugging had successfully prevented contamination of the aquifer from the overlying Boone aquifer. As part of the Roubidoux Ground Water Monitoring Program, it was further recommended that the Roubidoux background

reassessment proposed by the ODEQ be conducted to verify that the indicator parameters, background concentrations, and tolerance limits used as triggers to indicate acid mine water influx from the Boone aquifer to the Roubidoux aquifer are appropriate. The ODEQ continued the Roubidoux Ground Water Monitoring Program at the site to monitor the quality of the water in the Roubidoux aquifer during the current five-year review period. The ODEQ issued a report on the results of the Roubidoux Ground Water Monitoring Program documenting activities through 2002. In this report, the ODEQ concluded:

- That well improvements were only a temporary result of isolation of the Roubidoux aquifer from the contaminated Boone ground water, indicating both well integrity problems and impacted Roubidoux aquifer at these sites.
- The report also concluded that use of inflatable packers and Polyvinyl Chloride (PVC) liners in the five impacted municipal wells was not adequate to ascertain whether the Roubidoux aquifer near them is being impacted by contaminated Boone water through inadequate or deteriorated well casing.
- The report further concluded that the extent of adverse impacts to the Roubidoux from contaminated mine water near Picher was not well defined by the study.
- The project demonstrated that a new well could be completed in the Roubidoux aquifer within the mine field and produce ample supply of good quality drinking water.

The ODEQ recommended:

- Continuation of the Roubidoux Ground Water Monitoring Program.
- A trend analysis to be performed on the data.
- That Roubidoux wells continue to be evaluated for plugging.
- An additional well (or wells) to be installed near Quapaw to better delineate the extent of mine water contamination in the Roubidoux in that area.
- An evaluation of treatment options for impacted Roubidoux water.
- That a map delineating a two-mile buffer zone around surface mine waste and underground mine workings be compiled to use as a notification of impaired water quality in the Boone and shallow aquifer, and that any well completed in the Roubidoux within this zone be constructed with casing to no less than 850 ft bgs, with an additional 250 ft bgs intermediate casing to seal off the Boone aquifer.
- That well drillers be notified of this area of contamination.
- A network of perimeter monitoring wells is needed to define and monitor Boone ground water contamination and migration.

The 2003 to 2008 results of the Roubidoux Ground Water Monitoring Program are presented in [Table 2](#) and discussed further in [Section 6.4](#).

The third five-year review report recommended that the EPA continue plugging and abandoning Roubidoux wells as they are identified. The ODEQ has identified 19 wells that require further assessment for plugging. The wells need to be located, assessed to determine if they are completed in the Roubidoux aquifer, and evaluated to determine if it is technically feasible to plug those wells that are located and determined to be completed in the Roubidoux aquifer (**ODEQ, 2006c**).

The OU2 RA was in progress during the third five-year review, and the report recommended that the RA be continued. The total number of residential properties and HAAs that have been remediated as part of the removal response actions and OU2 RA is 2,295 as of January 2010 (**EPA, 2010a**). The EPA is currently evaluating actions that are necessary to complete the OU2 RA. Reconnaissance efforts have identified chat in alleyways and driveways in Miami and other communities in Ottawa County. During the site inspection for this five-year review, chat was observed in the footprints of demolished homes in Picher, Cardin, and Miami. RA activities are now complete in Picher, Cardin, Quapaw, and North Miami, with the exception of further assessment of the footprints of the homes that have been demolished and removed as part of the voluntary relocation. The City of Commerce completed the RA for properties remaining in Commerce under an agreement with the ODEQ. Final reporting on this work has not yet been completed. Final reports on the remediation efforts performed by the Cities of Miami, Afton, and Fairland have not yet been completed as well.

Lastly, the third five-year review report recommended that the OU4 RI/FS, BHHRA, and ERA be conducted. The RI/FS and Proposed Plan for the site were made available to the public in July 2007, and the OU4 ROD was signed by EPA in February 2008 (**EPA, 2008**).

6.0 Five-Year Review Process

This fourth five-year review for the site has been conducted in accordance with the EPA's Comprehensive Five-Year Review guidance dated June 2001 (**EPA, 2001**). Interviews were conducted with relevant parties; a site inspection was conducted; and applicable data and documentation covering the period of the review were evaluated. The activities conducted as part of this review and specific findings are described in the following paragraphs.

6.1 Administrative Components

The five-year review for this site was initiated by the EPA. The review team was led by the EPA Remedial Project Manager (RPM) for OUs 1 and 2 at this site, Mr. Bob Sullivan/ EPA Region 6. The components of the review included community involvement, document review, data review, a site inspection, interviews, and development of this five-year review report, as described in the following paragraphs.

6.2 Community Involvement

A public notice announcing initiation of the five-year review was published in the Miami News Record on December 10, 2009. Upon signature, the fourth five-year review report will be placed in the information repositories for the site, including the Miami Public Library in Miami, and at the EPA Region 6 office in Dallas, Texas. A notice will then be published in the Miami News Record to summarize the findings of the review and announce the availability of the report at the information repositories. Copies of the two public notices are provided as [Attachment 5](#) to this report.

6.3 Document Review

This fourth five-year review for the site included a review of relevant site documents, including decision documents, construction and implementation reports, sampling reports, and related monitoring data. Documents reviewed are listed in [Attachment 1](#).

6.4 Data Review

The Roubidoux Ground Water Monitoring Program continued during the current five-year review period, and sampling was conducted from November 2003 to April 2008. Wells used in the monitoring program included the five monitoring wells installed by ODEQ as part of the Roubidoux Ground Water Monitoring Program (Commerce #5, Quapaw #5, Picher #5, Picher #6, and Picher #7), one municipal supply well located within the mining area (Cardin #1), four wells located on the edge of the mining area (Commerce #4, one private well, Quapaw #4, and the Rural Water District #4 Well #4 [RWD4 #4]), and four wells located outside of the mining area (Miami #1, Miami #3 [replaced Miami #1 in program], Miami #11, and RWD7 #2). The private well is located at the former smelter location south of Hockerville. This well was reportedly used by the smelter, and is now used as a private water supply well. The locations of each well are shown on [Figure 4 \(ODEQ, 2008b\)](#).

The 2003 to 2008 results from the Roubidoux Ground Water Monitoring Program are included in [Table](#)

2. The private well was sampled on multiple occasions to determine the baseline conditions for the indicator parameters at that well. The ODEQ defines a well that produces water with concentrations in excess of the tolerance limits for all three indicator parameters as impacted by mine water locally near the well site, a well that produces water with concentrations in excess of the background concentrations for all three indicator parameters and above the tolerance limits for two of the indicator parameters as probably impacted by mine water locally near the well site, and a well that produces water with concentrations in excess of the background concentrations for two of the three indicator parameters and above the tolerance limits for one of the indicator parameters as possibly impacted by acid mine water locally near the well site.

The Quapaw #5 MW well results show that the well is still impacted by acid mine water as indicated by concentrations of sulfate, iron and total dissolved solids (TDS) above the Secondary Maximum Contaminant Levels (SMCLs) (averaging 416.5 mg/L, 2.8 mg/L and 1029 mg/L, respectively), as well as concentrations of zinc above the Roubidoux tolerance limit (averaging 0.144 mg/L). Three of the wells (the private well, Picher #5 MW, Picher #6 MW) are probably impacted by acid mine water as indicated by elevated concentrations of sulfate, iron and TDS above the tolerance limit of the Roubidoux and many exceedences of the SMCL for iron (Picher #6 MW and private well), some exceedences of the MCL for lead (private well), and some exceedences of the SMCLs for iron (Picher #5 MW), sulfate (private well), and TDS (private well). The results indicate that 3 wells (Cardin #1, Commerce #4, and Picher #7 MW) are possibly impacted by acid mine water as indicated by concentrations of sulfate above tolerance limits for the Roubidoux. The results indicate that 7 of the wells (Miami #1, Miami #3, Miami #11, RWD4 #3, Quapaw #4, Commerce #5 MW, and RWD7 #2) are not impacted by acid mine water.

The EPA performed statistical trend evaluations for the Roubidoux ground water data collected between 2003 and 2006. This evaluation stated there was very little evidence of upward or downward trends in concentration for the analytical parameters overall. Only five percent of the cases demonstrated an upward or downward trend. For the indicator parameters of iron, zinc, and sulfate, an upward or downward trend was noted in 20% of the cases. The report documenting the evaluation stated that five percent is the number of significant trends expected in random data, and overall this level of trends equates with a stable aquifer. With respect to the indicator parameters, the report draws the same conclusion (the aquifer is relatively stable with regards to concentration trends for the indicator parameters). The only increasing trends were for sulfate in three wells. The data reviewed indicated that out of the 571 analytical results reviewed, MCLs were exceeded only four times by individual concentrations (for arsenic in Quapaw #5 and for total and dissolved lead in a private well). These

exceedences occurred during 2003 and 2004 and did not occur in public drinking water wells. A study of the upper confidence limits (UCLs) show there were no aquifer-wide issues relative to the OWQS, although iron concentrations in Quapaw #5 were elevated (**CH2M HILL, 2007e**). No MCL exceedences were noted in the data from 2005 through 2008.

The Roubidoux Ground Water Monitoring Program was recently extended to cover the period of October 2009 to October 2013. ODEQ, funded by EPA, will sample Miami #1, Miami #3, Miami #11, Commerce #5, Commerce #4, Cardin #1, Picher #5, Picher #7, Picher #6, Quapaw #4, Quapaw #5, RWD4 #3, and RWD7 #2, 13 wells total. Wells will be sampled annually in October. Water samples will be analyzed for total metals, dissolved metals, and general chemistry (**ODEQ, 2009a**).

An Advanced Screening Level Ecological Risk Assessment (SLERA) was performed for the Tri-State Mining District (TSMD) as a whole, including the Tar Creek Superfund Site. This study describes the results of two ecological risk assessments (ERAs), including a SLERA for aquatic and riparian habitats to evaluate risk to ecological receptors and a detailed ERA to assess risks to the benthic invertebrate community. Data that had been collected at the site between 2002 and 2009 to describe conditions within the watershed were compiled. The results of the SLERA indicated that the presence of COPCs in surface water, whole sediments, pore water, and/or soil poses potential risks to ecological receptors. The Detailed Ecological Risk Assessment indicated that exposure to metals in sediments poses moderate to high risks to benthic invertebrates at approximately 45% of the locations samples during the study, including portions of Tar Creek and Lytle Creek (MacDonald, D. et al., 2010).

An integrated site assessment and investigation of Tar, Lytle, Elm and Beaver Creeks took place in Spring 2009. Surface water, pore water, and sediment sampling was performed to evaluate impacts to site streams from site source materials (primarily mine tailings). The surface water data are provided in **Table 4**, and the sediment data are provided in **Table 5**. The sampling locations are provided on **Figure 5**. Concentrations of cadmium, lead, and zinc range from the tens to tens of thousands of milligrams per kilogram (mg/kg) in local stream sediments and micrograms per liter in local streams. The narrative and numerical criteria in the OWQS are designed to maintain and protect the beneficial surface water use classification of "Fish and Wildlife Propagation". Under the OWQS there are numerical "Toxic Substance" concentration limits for surface water with both "acute" and "chronic" standards listed. Under 785 OAC 45 OWQS, "acute toxicity" means the surface water concentration of a toxic substance is such that it means greater than or equal to 50% lethality to appropriate test organisms in a test sample. Under those same standards, "chronic toxicity" means the surface water concentration of a toxic substance is such that there is a statistically significant difference (at the 95% confidence level) between longer-term

survival and/or reproduction or growth of the appropriate test organisms in a test sample and a control. Teratogenicity and mutagenicity are considered to be effects of chronic toxicity. In Tar Creek, Lytle Creek, and Elm Creek at the Tar Creek Site, EPA found that cadmium, lead, and zinc concentrations in surface water samples exceed the OWQS chronic toxicity standard, and zinc concentrations also exceed the acute toxicity standard.

6.5 Interviews

During the course of the five-year review, interviews were conducted with several parties involved with the site: (1) Mr. Dennis Datin, ODEQ; (2) Ms. Kelly Dixon, ODEQ; (3) Ms. Angela Hughes, ODEQ; (4) Mr. David Cates, ODEQ; (5) Mr. Jim Dixon, Environmental Director of the Peoria Tribe of Indians of Oklahoma; (6) Dr. Mark Osborn, LICRAT; (7) Ms. Rebecca Jim, Local Environmental Action Demanded (LEAD). Interview questionnaires were sent to 21 individuals, and responses were received from the seven listed above. Interview records forms which document the issues discussed during these interviews are provided in [Attachment 2](#).

Overall, the impression of the work done at the site has been positive. Mr. Jim Dixon, environmental director of the Peoria Tribe, however, believes that much of the remedial effort has been inadequate or ineffective and that the remedies are not based on thorough science. He raises concerns about the potential contamination of the Roubidoux aquifer and area surface waters from injection, and he also raises concerns about the integrity of the chat repository. Kelly Dixon/ODEQ, has concerns about the size and cost of the repository and whether or not marketable chat will be deposited instead of sold.

The impact on the community is perceived by the interviewees to be both negative and positive. According to the interviews, the community is engaged and is glad that remediation is taking place. However, the work tends to be invasive and the community is experiencing fatigue at the length of the remediation effort and the continued presence of government agency personnel in the area. Kelly Dixon, ODEQ, suggests creating and maintaining a community outreach office in the area.

Kelly Dixon and David Cates of ODEQ would like to lift the restricted use standards for Tar Creek and question the waiver of ARARs, based on fund balancing criteria, for the remediation of the Tar Creek surface water. According to Mr. Cates and Ms. Dixon of ODEQ, the passive treatment wetlands system located in Commerce has been successful in treating discharging mine water and should be evaluated for the treatment of other mine water discharging into Tar Creek and Beaver Creek at other locations.

The interviews indicated that the majority of the parties consider themselves to be well-informed. Kelly Dixon and David Cates of ODEQ essentially said that they wanted to be more fully informed concerning enforcement and settlement negotiations between DOJ, EPA, and the mining companies that EPA has identified as potentially responsible parties. Rebecca Jim/LEAD, would like more communication with her office by EPA and ODEQ. Jim Dixon did not feel well-informed due to time and budget constraints, and he essentially said that tribal input is perceived to be disregarded.

6.6 Site Inspection

An inspection was conducted at the site on December 14 and 15, 2009. The completed site inspection checklist is provided in [Attachment 3](#). Photographs taken during the Tar Creek Superfund Site inspection are provided in [Attachment 4](#).

The wells utilized by the ODEQ for the Roubidoux Ground Water Monitoring Program are sampled on an annual basis. All wells are secured in a locked building, behind a fence, or both. During the site inspection, Picher Well No. 6-MW was observed to be behind a fence ([Photograph 25](#)). A mine shaft collapse was observed on the east side of Picher near Picher Well No. 6-MW ([Photographs 26 – 27](#)).

The dike and diversion channel at the Muncie site was inspected. This site is located on the Treece Subsite of the Cherokee County Superfund Site, and the remediation contractor has been filling in the subsidence feature with source materials and soil and re-grading the land surface. At the time of the site inspection, the subsidence feature at the Muncie site was almost completely filled in and portions of the diversion dike had been removed ([Photographs 5 – 14](#)).

The improved stream channel at the Big John site was observed from the public right-of-way. The stream channel improvements appeared to be functioning properly. Rip-rap was present along the cut-banks of the channel and there were no signs evident that the stream was eroding the channel. This area contains chat at the surface. The ROD Amendment for the Treece Subsite indicates that this area of the site will be remediated in a similar manner to the Muncie site ([EPA, 2006](#)). Remediation work associated with the Cherokee County site was not observed at the Big John site at the time of the site inspection ([Photographs 15 - 22](#)).

The dike at the Admiralty site was inspected. The small collapsed portion of the dike, observed during the second five-year review site inspection, is still present, and erosion of the dike was observed on the upstream side of the dike adjacent to the small collapse in the center of the dike. It was not possible to

determine if this collapse had reformed since the third five-year review site inspection or had not been adequately repaired following the third five-year review site inspection. The vegetation is well established on the dike and slightly overgrown. The Lytle Creek diversion channel was clear and functioning properly (**Photographs 39 – 46**).

The acid mine water discharges to Tar Creek at the Douthat Bridge on E40 Road were observed. Acid mine water flows into Tar Creek at the northeast corner of the bridge, and the impact to the surface water in the stream is apparent on the south side of the bridge (**Photographs 76 – 83**).

Two soil repositories (locations where the soil from the OU2 RA yard remediation work is disposed) have been used at the site. The South Repository is located on private land on E40 Road, west of the Douthat Bridge (**Photographs 84 – 86**). This repository is located at the site of the former Eagle-Picher Central Mill. The soil from the OU2 remediation work has been used at this location to fill in and cover an old mill tailings pond. The South Repository was secured by a locked gate and barbed wire fence. Although the site inspection occurred during winter, it was apparent that the repository is well vegetated.

Chat was observed in alleyways and driveways in the City of Miami (**Photographs 47 – 50**). A number of properties were bought out in an area along Tar Creek on the east side of Miami due to flooding that occurred in 2007. On several properties, the houses had been removed, and chat was observed in the footprints of the houses (**Photograph 87**). A reconnaissance effort was in progress at the time of the site inspection to locate and identify alleyways and driveways in areas of Ottawa County outside of the mining area.

The voluntary relocation being conducted under OU4 is currently in progress. Most residents have been relocated through this program, and many of the properties were being cleared to remove structures and debris (**Photographs 52 – 53** and **59**). Suitable houses were being relocated to a new residential subdivision being developed along Beaver Creek southeast of Quapaw (**Photograph 59**). Contractors of LICRAT were performing work during the site inspection to clear and remove buildings (**Photographs 29** and **38**). Although most of the residents have accepted the voluntary relocation, there were still a few residents living in the area and there were a few business open in Picher (**Photographs 30** and **53 – 54**). Chat was observed in the footprints where houses once stood (related to OU2) (**Photographs 23 – 24**, **51**, and **55 – 57**).

During the site inspection, the chat washing operation and injection pilot study was observed at the Sooner Chat Pile (**Photographs 60 – 67**). The constructed wetlands treatment system located southeast of Commerce, constructed and operated by the University of Oklahoma, was also observed during the site inspection (**Photographs 68 – 75**).

7.0 Technical Assessment

The five-year review must determine whether the remedy at a site is protective of human health and the environment. The EPA guidance lists three questions used to provide a framework for organizing and evaluating data and information and to ensure all relevant issues are considered when determining the protectiveness of a remedy. These questions are answered for the site in the following paragraphs. At the end of the section is a summary of the technical assessment.

7.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

The documents that memorialize the remedy selection decisions for the site are the June 1984 ROD for OU1, the August 1997 ROD for OU2, the March 2000 Action Memorandum for OU3, and the February 2008 ROD for OU4. O&M and the Roubidoux Ground Water Monitoring Program are ongoing for OU1. The RA for OU2 continues. OU3 was a removal response action and requires no further action. The RD/RA for portions of the selected OU4 remedy began in 2009. This section discusses the RA performance, O&M, costs, ICs, monitoring activities, opportunities for optimization, and early indicators of potential remedy problems.

RA Performance. Based on the data review, the site inspection, and the interviews, it appears that the various Tar Creek Superfund Site remedies selected in the OU1 and OU2 RODs are functioning as intended.

As noted in previous five-year reviews, the diking and diversion work performed as part of the OU1 remedy was not successful at reducing the discharges of acid mine water to Tar Creek. The first five-year review documents the assessment of the remedy relative to surface water inflow into the mines and acid mine water discharges from the mines. Although the diking and diversion structures did affect recharge to the mines associated with rainfall events, discharges from the mines to Tar Creek were not reduced. The diking and diversion portion of the remedy was at best only partially effective (**EPA, 1994a**). The ODEQ has identified 19 wells at the site that are potentially completed in the Roubidoux aquifer. These wells still require assessment to determine if the wells still exist and their location, as well as determining

if the wells are completed in the Roubidoux aquifer and if it is technically feasible to plug those wells completed in the Roubidoux aquifer (**ODEQ, 2006b**).

The RA for OU2 is still in progress. Blood lead data collected from children at the site have demonstrated that the OU2 remediation is effective, with only 2.8 percent of children between the ages of one and five residing at the site having a blood lead level that exceeds 10 µg/dl. This percentage is slightly higher than the average for the nation as whole (2.2 percent) (**EPA, 2010a**). Most actions for OU2 have been completed, but there are still activities necessary to assess potential soil contamination associated with chat present in alleyways and driveways in portions of Ottawa County outside the mining area, and removed building footprints in residential areas associated with the voluntary relocation and with several homes located in Miami that were bought out and removed due to flooding issues. Final closure of the two soil repositories needs to be performed in accordance with the OU2 ROD once all RA activities are completed, and the ICs stated in the OU2 ROD will need to be filed in the property records.

The voluntary relocation being performed by LICRAT and funded by EPA as part of the OU4 remedy is in progress. The voluntary relocation will remove most residents from the most impacted portions of the mining area and reduce the potential for exposure to site-related contamination. RA activities for OU4 began in late 2009.

Operation and Maintenance. The OU1 ROD discusses O&M costs related to the diking and diversion portion of the selected remedy. O&M activities for the dikes and diverted creek channels are ongoing at the site. The Muncie and Big John sites are located in Kansas and are within the Treece subsite of the Cherokee County site. The dike around the Muncie site is being removed as part of the remedy for the Treece Subsite and the subsidence feature is being filled in. The source materials in the area around the Big John subsidence will be addressed in a similar manner. Removal of the subsidence features will remove these pathways for surface water inflow into the mine workings, and the dikes will no longer be necessary to divert surface water away from these locations. Continued O&M will no longer be required. O&M at the Admiralty site, located in Oklahoma, should be performed to address the hole and erosion noted in the dike during the site inspection.

The OU2 ROD calls for O&M to maintain the south repository and any supplemental ICs (discussed below). Both soil repositories have been vegetated to prevent or reduce erosion. The OU2 ROD states that a clean soil cap would be placed on those areas of the repositories where the soil lead concentrations

exceeded the remediation goal (500 ppm). The south repository is a former dry tailings pond that is included in the RA for OU4 and may be capped according to the requirements of the OU4 ROD.

Costs of Operations and Maintenance. The OU1 ROD states that O&M costs related to the diking and diversion portion of the selected remedy would be approximately \$5,000 per year. No costs associated with the Roubidoux Ground Water Monitoring Program were provided in the OU1 ROD. No O&M costs associated with the O&M of the Admiralty dike and stream diversion were provided by ODEQ as part of this five-year review. Maintenance of the Muncie and Big John sites, located at the Cherokee County Superfund Site, will no longer be required once the subsidence features are currently filled in as part of the RA for the site. The dikes will no longer be required to prevent the flow of water into the subsidence features. O&M at the Admiralty site is performed by the ODEQ. Costs for O&M associated with OU1 are not considered an issue relative to the protectiveness of the remedy. Maintenance of the dikes and diversion channels has been minimal since the OU1 RA was completed. The Roubidoux Ground Water Monitoring Program has been revised through the years to obtain the data necessary to assess the water quality of the aquifer. Sampling currently occurs on an annual basis to ensure that the drinking water supply is safe.

The OU2 ROD states that O&M associated with maintaining the soil repositories and ICs would be \$60,000 per year. RA activities are ongoing, and no O&M costs have been incurred associated with OU2.

Implementation of ICs. ICs are generally defined as non-engineered instruments such as administrative and legal tools that do not involve construction or physically changing the site and that help minimize the potential for human exposure to contamination and/or protect the integrity of a remedy by limiting land and/or resource use (**EPA, 2005**). ICs can be used for many purposes including restriction of site use, modifying behavior, and providing information to people (EPA, 2000). ICs may include deed notices, easements, covenants, restrictions, or other conditions on deeds, and/or ground water and/or land use restriction documents (**EPA, 2001**). The following paragraphs describe the ICs implemented at the site, the potential effect of future land use plans on ICs, and any plans for changes to site contamination status.

The OU1 ROD did not call for the use of ICs (**EPA, 1984**).

Potential ICs for OU2 are listed in the OU2 ROD. These ICs may include:

- 1) Restrictions and management controls on unsafe uses of mine tailings;

- 2) Restrictions and management controls on activities that would cause recontamination of remediated properties;
- 3) Restrictions and management controls on activities that would contaminate clean site property with mine tailings;
- 4) Restrictions and management controls intended to prevent future exposure of children to unacceptable levels of lead in the soil at new residential developments that are located in areas with high lead levels in soil;
- 5) Restrictions and management controls on building and construction activities in order to prevent building and construction practices that would increase exposure to lead-contaminated soils;
- 6) Restrictions and management controls on access to contaminated property through physical barriers (e. g., fencing) or notices (e. g., warning signs);
- 7) Public health and environmental ordinances and controls related to lead exposure and management of mine tailings;
- 8) Placing notices in property deeds regarding contamination;
- 9) Sampling and analysis of lead sources;
- 10) Blood lead monitoring;
- 11) Health education; and,
- 12) Lead-contaminated dust reduction activities (**EPA, 1997**).

The preceding ICs are optional under the OU2 ROD. The OU2 ROD stipulated that all ICs may not be necessary, or that some would only be used in special circumstances as dictated by conditions encountered at a specific property during the RA. In addition, the ROD stated that authorities of other government entities might be required to implement some of the ICs (e. g. zoning restrictions would require the municipal authority, lease restrictions might require DOI authority, etc). The ROD further stated that many ICs, such as community-wide health education, community-wide blood lead monitoring, and community-wide lead-contaminated dust reduction activities were appropriate for application in residential areas throughout Ottawa County (**EPA, 1997**).

With respect to safe uses of mine tailings (item 1 above), chat is viewed as a commercial resource in the community at the site. Continued chat sales is included as part of the final remedy for OU4. Prior to signing the OU4 ROD, EPA promulgated regulations regarding the safe use of chat in transportation construction projects (40 CFR 278). In selecting continued chat sales as part of the OU4 remedy, the OU4 ROD requires that all site chat that is used, on-site or off-site, must be managed according to the criteria provided in the Chat Rule, 40 CFR Part 278, and its preamble (including EPA's June 2007 fact

sheet; EPA530-F-07-016B). The Chat Rule regulations apply to transportation construction projects, and the preamble guidance applies to non-transportation, non-residential projects. The Chat Rule and its preamble were included in the OU4 ROD as requirements for the use of site chat (**EPA, 2008**).

The OU4 ROD further states that the chat sales program outlined in the OU4 ROD is part of the CERCLA remedy, and activities undertaken in support of chat sales are undertaken pursuant to CERCLA authority and are part of the CERCLA response action. Continued chat sales would contribute to a more cost effective CERCLA remedy because it would result in less chat remaining on-site to be addressed with more expensive remedial alternatives (i.e., remedial alternatives that are more costly than chat sales), and continued chat sales would result in less chat disposed of on-site. The OU4 ROD stipulated that EPA did not own any chat and would not purchase any chat. However, the EPA would provide guidance to chat sales participants as part of the OU4 remedy (**EPA, 2008**). The EPA has conducted numerous workshops with site stakeholders regarding chat sales and use (**EPA, 2010a**).

The ICs listed in items 9 – 12 above are currently being implemented through agreements between the EPA and the ATSDR and OCHD or as part of the OU2 RA. The EPA funds the ATSDR and OCHD to perform blood lead screening and health education activities at the site (**EPA, 2010a**). During the site inspection conducted for this five-year review, it was noticed that numerous signs were posted in various public areas at the site warning of the dangers associated with lead contamination and chat. Outside of the RA work, lead-contaminated dust reduction activities are part of the community education efforts. Once the RA activities for OU2 are completed, the EPA will work with the various authorities (city, county, state, and federal) to implement any of the additional listed ICs necessary to maintain the protectiveness of the remedy.

ICs for OU4 are listed in the OU4 ROD. The ROD specifies ICs to restrict use of properties where covered fine tailings or on-site repositories are located, and properties acquired via the voluntary relocation by filing of deeds of notice and easement. In addition, the ROD requires an IC to restrict future uses of ground water from the portion of the Boone aquifer and any shallower ground water that is impacted with site-related contaminants above the Final Remediation Goals for potable or domestic supply. The OU4 ROD requires that ground water be restricted via the OWQS Title 785, Chapter 45, Appendix H. Appendix H states that the Boone aquifer in Ottawa County is a Class II ground water source suitable for use as a water supply, for agriculture, and municipal and industrial processes. This information is amended with a remark stating “Toxic metals, special well construction required”. However, the method of special well construction is not specified, nor is any statement made regarding

how the toxic metals are to be discovered or addressed if they are found in ground water. The most recent revision of Chapter 45 was released May 27, 2008, and according to the OWRB website the next revision, which does not address the point above, is anticipated to be released in 2010 (**EPA, 2008, OWRB, 2008**). The OU4 RI only found two private wells that were impacted above the Final Remediation Goals that are being used as drinking water sources. These two residents are to be provided an alternate drinking water supply as part of the OU4 RA (**AATA, 2005**).

Monitoring Activities. The Roubidoux Ground Water Monitoring Program continues under OU1. The program is implemented by ODEQ and funded by EPA to assess and monitor the effectiveness of the well plugging portion of the remedy in terms of protection of the Roubidoux aquifer. The data collected through the sampling indicates that the Roubidoux aquifer is impacted locally by acid mine water. The mechanism for acid mine water migration into the Roubidoux is not totally clear. To-date, the data collected regarding the connection between the Boone and Roubidoux aquifers indicate that the primary pathway for ground water and contaminants to migrate into the Roubidoux aquifer from the Boone aquifer and mine workings has been through abandoned wells, wells that have faulty casings and/or poor seals across the Boone Formation, and through unplugged abandoned boreholes (**CH2M HILL, 2008**, and **ODEQ, 2006b**). The statistical trend analysis performed on the data collected between 2002 and 2006 suggests that the water quality in the Roubidoux is stable with respect to the analytes monitored and with respect to the indicator parameters (**CH2M HILL, 2007e**). The drinking water supplied from the Roubidoux aquifer in the mining area continues to meet the health-based primary drinking water standards (MCLs), and it is still considered safe for use as a drinking water supply.

Opportunities for Optimization. O&M to maintain the dikes and diversion channels at the Muncie and Big John sites will no longer be necessary as a result of the RA for the Treece Subsite of the Cherokee County site. The ODEQ is responsible for O&M of the dike and diversion channel at the Admiralty Mine Site. The third five-year review states that the O&M Plan for this site dates to 1987 and should be updated. No O&M Plan document was available as part of this five-year review. Opportunities to optimize O&M activities at the Admiralty site were not examined due to the lack of an updated written plan. O&M for OU2 will begin once the RA construction activities are completed.

The ODEQ continues to implement Roubidoux Ground Water Monitoring Program. The program includes sampling of 14 wells annually (**ODEQ, 2009a**). Previous sampling was performed semi-annually. The reduction in sampling frequency is appropriate and reduces costs associated with the sampling efforts. In over 20 years of monitoring the Roubidoux aquifer, no public drinking water supply

wells have exhibited concentrations above MCLs. The remedy could be further optimized by performing statistical and trends analyses on the data collected since 1987 to assess the long-term trends and changes in the water quality of the Roubidoux. Such an analysis could be used to justify further changes to the monitoring program such as reduced sampling frequency, sampling fewer wells, and for making recommendations on continuing the sampling program in the future.

Early Indicators of Potential Remedy Problems. As noted in [Section 6.6](#), a small collapse exists in the diversion dike at the Admiralty Mine site, and some minor erosion has occurred on the upstream face of the dike. No other problems were noted during the site inspection.

As noted in previous five-year reviews, the discharges of acid mine water to Tar Creek have not decreased significantly since the construction of the dikes and diversion channels.

An IC restricting domestic and potable use of ground water from the Boone aquifer and shallow ground water containing concentrations of site-related contaminants that exceed the final remediation goal, as stated in the OU4 ROD, has not been put in place.

7.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and Remedial Action Objectives Used at the Time of the Remedy Selection Still Valid?

This section addresses changes in environmental standards, newly promulgated standards, and To-Be-Considereds (TBCs), changes in exposure pathways, and changes in toxicity and other contaminant characteristics during the five-year review period, and progress toward meeting Remedial Action Objectives (RAOs). Changes in promulgated standards or TBCs and assumptions used in the original definition of the RA may indicate an adjustment in the remedy is necessary to ensure the protectiveness of the remedy.

Changes in Exposure Pathways. There have been no changes in exposure pathways for the Tar Creek Superfund Site since completion of the third five-year review. Future land uses are not expected to change, and agricultural uses and rural residential uses will remain dominant on the site. A change is expected for residential and commercial settings in areas included in the voluntary relocation. Future land use of the properties that are purchased as part of the voluntary relocation effort being conducted by LICRAT is stipulated in LICRAT's enabling legislation. A restriction is required for these properties which shall run with the land on the property deed. The restriction will contain a provision that the

property may not be occupied by children six years of age and younger until the State formally determines that the area is safe for children of such an age. The voluntary relocation effort will reduce human health exposure pathways to site-related contaminants. As described below, the OWRB lowered the designated use of Tar Creek. In addition, no new contaminants or routes of exposure have been identified for OUs 1, 2, 3, or 4 as part of this five-year review. Finally, risk assessment methodology has not changed significantly since issuance of the OU2 ROD in August 1997 or the OU4 ROD in 2007, such that the protectiveness of the remedies might be called into question.

Subsequent to the issuance of the OU1 ROD, the State of Oklahoma concluded that the impacts to Tar Creek (i.e., impaired water chemistry and habitat) rendered the stream not adequate to support a "Warm Water Aquatic Community." The OWRB, the agency charged with setting Water Quality Standards for the State of Oklahoma, has also concluded that the impacts to Tar Creek are due to "irreversible man-made damages" resulting from past mining operations at the site.

To reflect this conclusion, the OWRB in 1985 lowered the designated uses of Tar Creek to a habitat limited fishery and to a secondary recreation water body. The OWRB's reference to "irreversible man-made damages" is a simplified rephrasing of the following language: "human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied." This wording is taken from paragraph 785:45-5-12 (b) (3) of the OWQS. Irreversible man made conditions are one of the allowable justifications for lowering a stream's classification from warm water fishery to a habitat-limited fishery.

The secondary recreation water body designation allows for uses where ingestion of water is not anticipated (e.g., boating, fishing, or wading). The OWQS associated with these designated uses are not being met in Tar Creek at present. In particular, the pH standard and the numerical criteria for toxic substances (e.g., heavy metals) which apply to all fishery classifications, including habitat-limited fisheries, are not being met. (The pH relates to the acidity of the water. Lower pH means more acidic conditions. A pH of 7 is neutral, neither acidic nor alkaline.)

The OU1 ROD contained numerous findings relative to the conditions and risks posed by contaminants from the site. The OU1 ROD specifically stated that:

- Fish fillet samples from the mouth of Tar Creek, the Neosho River, the Spring River, and Grand Lake are safe for human consumption.

- The sediments provide a long-term sink for metals that effectively removes the metals from most biological processes.

Additional data collection efforts at the site call into question the above statements that were made in the OU1 ROD. The OU1 ROD's exposure assumptions and the OU1 ROD's discussion of potential risks posed to human health and the environment for surface water and sediments at the site are no longer valid. Recent site data demonstrate that potential risks to human health exist through consumption of fish caught from Tar Creek, the Spring and Neosho Rivers, and Grand Lake. Metals contained within site sediments are biologically available and pose risks to ecological receptors. The narrative and numerical criteria in the OWQS are designed to maintain and protect the beneficial surface water use classification of "Fish and Wildlife Propagation". Under the OWQS there are numerical "Toxic Substance" concentration limits for surface water with both "acute" and "chronic" standards listed. Under 785 OAC 45 OWQS, "acute toxicity" means the surface water concentration of a toxic substance is such that it means greater than or equal to 50% lethality to appropriate test organisms in a test sample. Under those same standards, "chronic toxicity" means the surface water concentration of a toxic substance is such that there is a statistically significant difference (at the 95% confidence level) between longer-term survival and/or reproduction or growth of the appropriate test organisms in a test sample and a control. Teratogenicity and mutagenicity are considered to be effects of chronic toxicity. In Tar Creek, Lytle Creek, and Elm Creek at the Tar Creek Site, EPA found that cadmium, lead, and zinc concentrations in surface water samples exceed the OWQS chronic toxicity standard, and zinc concentrations also exceed the acute toxicity standard.

Changes in Toxicity and Other Contaminant Characteristics. The BHHRA for OU2 identified lead as the only site-related chemical of concern. The cleanup level of 500 mg/kg for lead in soils meets the EPA's goal of limiting soil lead levels such that a typical (or hypothetical) child or group of similarly exposed children would have an estimated risk of no more than 5 percent exceeding the 10 µg/dL. This blood-lead level was established by the CDC as a level of concern at which scientists studying large populations observed adverse health effects, including problems with learning and behavior, in groups of children with blood lead elevations at or above this level. Lead affects multiple target systems in adults and children; however, young children (generally seven years of age and younger) are at greatest risk from the effects of lead. The EPA's guidance on establishing cleanup levels for lead in soil has not changed (**EPA, 1994b**) so the site-specific cleanup level of 500 mg/kg is still suitable.

The BHHRA for OU4 identified lead as the primary chemical of concern and determined that addressing

exposure from lead will also be protective for cadmium and zinc exposure. At OU4, areas contaminated with source material are subject to frequent recreational use by adolescents. The EPA selected a remediation goal for adults that will ensure that a fetus of a woman of childbearing age will have no greater than a 5% chance of having a blood lead level greater than 10 µg/dL. The adult lead model (ALM) was used with site-specific exposure assumptions to come up with a preliminary remediation goal for lead in soil. The ALM predicts that a 500 ppm remediation goal for lead in source materials will protect adolescents who use these areas for recreation, because it provides protection to the more sensitive future fetuses of female adolescents who use these areas for recreation. As explained in the OU2 ROD, the 500 ppm remediation goal will also be protective for younger children in the event they come in direct contact with source material. EPA's guidance on establishing cleanup levels for lead in soil has not changed so the site-specific cleanup level of 500 mg/kg is still suitable (**EPA, 1994b**).

Since the BHHRA for OU4 was performed, the only change in toxicity values for cadmium and zinc is the inhalation reference concentration (RfC) for cadmium. In the BHHRA, the value of 2.0E-04 milligram per cubic meter (mg/m³) from National Center for Environmental Assessment (NCEA) was used to estimate risk. The cadmium RfC has been updated in EPA's Regional Screening Levels (RSL) table (EPA 2009) to 1.0E-05 mg/m³ from ATSDR. This update would affect the inhalation of ambient air pathway hazard estimates provided in the BHHRA. The hazard estimates would be slightly underestimates. Since the hazard estimates associated with this pathway are well below the noncancer threshold of 1 (0.00091 for the current general public and 0.00061 for the current and future residents including subsistence activities), the updated toxicity value does not affect the conclusions or recommendations of the risk assessment.

Changes in Environmental Standards, Newly Promulgated Standards, and To-Be-Considereds. ARARs for this site were identified in the RODs for OU1, OU2 and OU4. This five-year review included identification of and evaluation of changes in the ROD-specified ARARs and TBCs to determine whether such changes may affect the protectiveness of the selected remedy. The ARARs and TBCs identified by the RODs for the Tar Creek Superfund Site include chemical-, action- and location- requirements. These ARARs and TBCs are described below.

OU1 ROD (signed on June 6, 1984)

Chemical-Specific Requirements:

No contaminant-specific requirements were identified in the ROD.

Action-Specific Requirements:

No action-specific requirements were identified in the ROD.

Location-Specific Requirements:

1. Executive Order on Floodplain Management, Executive Order No. 11988.
2. Executive Order on Protection of Wetlands, Executive Order No. 11990.

The first five-year review report identified the additional following ARARs for the OU1 remedy:

Chemical-Specific Requirements:

1. OWQS, Oklahoma Administrative Code (OAC) 785:45.
2. Regulations regarding the discharge of wastewater to surface waters, Water Quality Criteria, 40 CFR 131.
3. National Primary Drinking Water Standards, 40 CFR 141.
4. National Secondary Drinking Water Standards, 40 CFR 143.

OU2 ROD (signed on August 27, 1997)

Chemical-Specific Requirements:

No chemical-specific requirements were identified in the ROD.

Action-Specific Requirements:

1. Regulations regarding the transportation of hazardous materials, 49 CFR 107, and 171-177.
2. CWA requirements regarding the use of BMPs and monitoring of discharges to assure compliance with effluent discharge limitations, 40 CFR 122.41 and 125.100.
3. Clean Air Act (CAA) requirements to control particulate emissions to ambient air, 40 CFR 50 and 60.

Location-Specific Requirements:

1. National Historic Preservation Act requirements to minimize effects to historic landmarks and to coordinate activities with the State Historic Preservation Officer (SHPO), 16 USC 470, et. Seq, and 40 CFR 6.301.

2. Archeological and Historic Preservation Act requirements to minimize effects on historical and archeological data and to coordinate activities with the SHPO, 16 USC 469, 40 CFR 6.301(b), and 36 CFR 800.
3. Historic Sites, Buildings, and Antiquities Act requirements to avoid undesirable impacts to such landmarks and to coordinate activities with the SHPO, 16 USC 461-467, and 40 CFR 6.301(a).
4. Endangered Species Act of 1973, Federal Migratory Bird Act, and Oklahoma Wildlife Statutes regulations and requirements requiring that endangered species and their habitat be conserved, and that consultation occur with the DOI and the Oklahoma State Department of Wildlife if such areas are affected, 16 USC 1531-1543, 50 CFR Parts 17 and 402, 40 CFR 6.302(h), 16 USC 703-712, and Oklahoma Statutes Title 29, Section 5-412.
5. Oklahoma Water Statutes limitations on the placement or discharge of deleterious, noxious, or toxic substances into affected waters of Oklahoma, Oklahoma Statutes Title 29, Section 7-401.
6. Rivers and Harbors Act of 1899 and CWA Section 404 requirements related to the Nationwide Permit for discharge of dredged or fill materials, 33 CFR 330 and 33 USC 1344.

OU4 ROD (signed on February 20, 2008)

Chemical-Specific Requirements:

1. Federal Safe Drinking Water Act MCL of 0.015 mg/L for lead, 40 CFR 141.8.

Action-Specific Requirements:

1. Regulations regarding the transportation of hazardous materials, 49 CFR 107, and 171-177.
2. CWA requirements regarding the use of pollution prevention plans (PPPs) and BMPs and monitoring of discharges to assure compliance with effluent discharge limitations, 40 CFR 122.26.
3. CAA requirements to control particulate emissions to ambient air, 40 CFR 50.6 (PM₁₀) and 50.12 (Lead).
4. SDWA addressing the UIC regulations for a Class V injection well, regarding injection of source materials into mine rooms, 40 CFR 144 UIC Program.
5. Oklahoma Solid Waste Management Act, monitoring of injected fluid, 27A O.S. § 2-6-701 et seq., Management of Solid Waste, Title 252 OAC, Chapter 652 UIC.
6. CWA, a watershed-based approach will be taken to address the potential effects RAs may have on the local watersheds, §404 33 CFR 320-330 and 40 CFR 230.
7. OWQS, monitoring wells installed during RA will be designed to comply with standards, OAC 785:45 Appendix H Beneficial Use Designations for Certain Limited Areas of Ground Water.
8. Oklahoma Statutes, ODEQ will file the deed notice upon completion of construction at each

individual property requiring engineering controls, 27A § 2-7-123(B).

9. Oklahoma Solid Waste Management Act and Management of Solid Waste, the design and construction of the repositories and covers for fine tailing ponds in the remedy will comply with established requirements, 27A O.S. § 2-10-101 et seq., Title 252 OAC, Chapter 515.

Location-Specific Requirements:

1. National Historic Preservation Act requirements to minimize effects to historic landmarks, 16 USC 470, et. Seq, and 40 CFR 6.301(b).
2. Endangered Species Act of 1973 regulations and requirements requiring that endangered species and their habitat be conserved, 16 USC 1531-1544, 40 CFR 6.302(h).

ARARs Involving Activities that are No Longer Occurring. The requirements listed below, which were previously identified as ARARs, apply to activities that are not currently taking place at the site or conditions that do not currently exist. Therefore, as a practical matter, they are not applicable to site remediation. However, should additional construction activities occur that affects flood plains or wetlands, these ARARs may be applicable.

The following ARARs are only applicable to the construction of the diking and diversion structures, and this construction is no longer occurring at the site.

1. Executive Order on Floodplain Management, Executive Order No. 11988.
2. Executive Order on Protection of Wetlands, Executive Order No. 11990.

Interpretation, Changes, and Revisions to Guidance and Regulations. The ODEQ, OWRB, and the Federal regulations have not been revised to the extent that the effectiveness of the remedy at the site would be called into question. No new regulations have been issued by the State of Oklahoma or the Federal government that would call into question the effectiveness of the remedy.

The EPA removed and reserved the regulations regarding BMPs at 40 CFR 125.100. Notice of the change was provided in the Federal Register (FR) on May 15, 2000 (see 65 FR 94 30886-30913). The EPA removed these regulations because the provisions under 40 CFR 125 Subpart K had never been activated. Also, the EPA determined that the requirements for implementing BMPs were better accomplished under the regulations at 40 CFR 122.44(k). The requirements of this regulation are applicable to the RA for OU2 at the site in regards to the use of BMPs to limit storm water discharges of pollutants.

Progress Toward Meeting the RAOs. The well plugging efforts performed for OU1 have been effective at removing this pathway for migration of acid mine water into the Roubidoux aquifer. Although data indicates the Roubidoux aquifer is impacted locally, primary drinking water standards have not been exceeded in public water supply wells, and the Roubidoux aquifer remains a usable source of drinking water.

The OU2 RA has attained the RAOs where remediation has been completed. Data indicate that the percentage of children residing at the site with elevated blood lead levels has declined significantly since the OU2 RA began. The OU2 RA is ongoing, and the remaining areas of the site to be addressed will meet the RAOs once the RA is complete.

7.3 Question C: Has any Other Information Come to Light that Could Call into Question the Protectiveness of the Remedy

The type of other information that might call into question the protectiveness of the remedy include potential future land use changes in the vicinity of the site or other expected changes in site conditions or exposure pathways. No other information has come to light as part of this fourth five-year review for the site that would call into question the protectiveness of the site remedy. Site investigations associated with OU5 are ongoing, and may identify additional exposure pathways to be addressed by a future ROD to be issued for OU5.

7.4 Summary of the Technical Assessment

The technical assessment, based on the data review, site inspection, technical evaluation, and interviews indicates that the RAs selected for the Tar Creek Superfund Site have been implemented as intended by the decision documents. Various other Federal, State, Tribal, and local government agencies are conducting studies and carrying out actions at the site to address the many environmental, health, and safety concerns associated with the site. The MOU signed between the USEPA, the USACE, and the DOI has brought together the Federal, State, Tribal, and local government and community stakeholders at the site. This has resulted in better communication and coordination of site activities between the various stakeholders to address the various issues associated with the Tar Creek Superfund Site. The cooperation of the various governmental agencies has led to coordinated use of the statutory and regulatory authorities of each to better address the complex issues at the site.

The ODEQ completed a follow-up fish tissue study of the site and downstream areas. Separate advisory levels were determined for both residents living within and those living outside of the Tar Creek area

using different background exposure assumptions (**ODEQ, 2007a**). As a result of the study, results were compiled into a revised fish consumption advisory that was released August 5, 2008. The advisory breaks out fish consumption suggestions on an easy-to-read chart for residents and non-residents of Tar Creek based on type of fish and location from which fish was caught (**ODEQ, 2008c**). This study is an indication that consumption of fish does pose a potential risk to human health, which contradicts the finding of the OU1 ROD.

An Advanced Screening Level Ecological Risk Assessment (SLERA) was performed for the Tri-State Mining District (TSMD) as a whole, including the Tar Creek Superfund Site. This study indicated that contaminants of potential concern (COPCs) present in surface water, sediments, pore water, and soils within riparian and aquatic habitats posed a potential risk to ecological receptors at the site. The Detailed Ecological Risk Assessment indicated that exposure to metals in sediments poses moderate to high risks to benthic invertebrates at approximately 45% of the locations sampled during the study, including portions of Tar Creek and Lytle Creek.

An integrated site assessment and investigation of Tar, Lytle, Elm and Beaver Creeks took place in March 2009. Surface water, pore water, and sediment sampling was performed to evaluate impacts to site streams from source materials. The results show that the majority of local streams have been adversely impacted by the deposition of coarse chat in the streams from previous mining activities at the Site. Concentrations of cadmium, lead, and zinc range from the tens to tens of thousands of milligrams per kilogram (mg/kg) in local stream sediments, and measure in the micrograms per liter in local stream surface water. Forty-six percent of the cadmium and lead surface water samples taken from Tar Creek exceeded the chronic threshold levels for fish and wildlife propagation. All of the zinc surface water samples in Tar Creek exceeded the acute threshold levels for fish and wildlife propagation in the OWQS.

The exposure assumptions in the OU1 ROD and the OU1 ROD's description of potential risks posed to human health and the environment by contaminated surface water and contaminated sediments at the site are no longer valid. Recent site data demonstrate that potential risks to human health exist if fish caught in site area streams are consumed by humans. Other recent findings show that metals contained within site sediments are biologically available and pose risks to ecological receptors. The concentrations of contaminants in Tar Creek continue to exceed the OWQS. Analytical results of the OU5 investigations of the surface water in Tar Creek indicate that levels of cadmium, lead, and zinc exceed OWQS for chronic threshold levels for fish and wildlife propagation. Additionally, all 28 samples exceed the OWQS acute threshold level for fish and wildlife propagation for zinc.

The drinking water supplied from the Roubidoux aquifer in the mining area meets the MCLs, and it is safe for use as a drinking water supply. The Roubidoux Ground Water Monitoring Program continues to monitor the aquifer to evaluate the effectiveness of the well plugging portion of the OU1 remedy at preventing acid mine water migration from the Boone aquifer to the Roubidoux aquifer. The data gathered since completion of the RA indicates that the Roubidoux aquifer is impacted locally by acid mine water. The statistical trend analysis of the data collected between 2003 and 2006 indicates that the aquifer is relatively stable with respect to the analytes sampled for, including the indicator parameters (**CH2M HILL, 2007e**). The OU1 ROD did not establish triggers that would indicate acid mine water has impacted the Roubidoux aquifer. Three indicator parameters and background concentrations and tolerance limit values were determined during an early phase of the Roubidoux Ground Water Monitoring Program. It should be noted that neither the EPA nor ODEQ have identified any public drinking water wells at the site that fail to meet the MCLs established under the SDWA. That is, the drinking water at the site is safe for all uses.

The OU1 ROD stipulated that the EPA would evaluate the need to plug additional abandoned wells at the site as they were identified. The ODEQ has identified 19 wells that need to be evaluated for plugging. The actual existence of each well still needs to be verified and the wells located. Each well will need to be assessed to verify that the well is completed in the Roubidoux aquifer and to determine the technical feasibility of abandoning each well completed in the Roubidoux aquifer (**ODEQ, 2006c**).

At the time of the site inspection, one area of collapse was observed on the dike constructed at the Admiralty site. Minor erosion was also present on the upstream face of the dike next to the collapse. This collapse was not large enough to allow water to pass through the dike at the time of the site inspection. A similar collapse was noted during the site inspection conducted as part of the third five-year review. The third five-year review indicated that the collapse was repaired, and it is unclear if the current collapse was at the same location or a different location. The erosion and collapse require repair. The O&M Plan for this site dates to 1987 and should be updated.

The remediation work conducted under the RA for OU2 is still ongoing. Chat has been identified in alleyways and driveways in areas of Ottawa County outside of the mining area, including the City of Miami. Chat has also been observed in the footprints of demolished homes associated with the voluntary relocation and homes demolished due to flooding in the City of Miami. There is still some OU2 RA work to be completed in Commerce. Once the OU2 RA actions are completed, the soil repositories will have to be closed in accordance with the requirements of the OU2 ROD and ICs filed on the properties.

Community education efforts are conducted at the site to alert the local residents to the health risks associated with lead contamination. An ATSDR study indicates that in 2003, 2.8% of children at the site have blood lead levels above 10 µg/dl (**ATSDR, 2004a**). The EPA continues to fund ATSDR and OCHD to provide continuing education efforts and blood lead monitoring associated with the site (**EPA, 2010a**).

The voluntary relocation being performed by LICRAT is in progress and anticipated to be completed in 2010. The voluntary relocation will remove most of the residents from the most impacted areas at the site, reducing the risk of exposure to site contaminants. Chat sales will continue to safely remove source materials from the site, limiting the volume of chat that will have to be addressed as part of the OU4 RA and limiting the land area that will be restricted as part of the OU4 RA.

The OU4 ROD requires that ground water be restricted via the OWQS Title 785, Chapter 45, Appendix H. Appendix H states that the Boone aquifer in Ottawa County is a Class II ground water source suitable for use as a water supply, for agriculture, and municipal and industrial processes. This information is amended with a remark stating “Toxic metals, special well construction required”. However, the method of special well construction is not specified, nor is any statement made regarding how the toxic metals are to be discovered or addressed if they are found in water (**EPA, 2008, OWRB, 2008**).

8.0 Issues

The O&M and Roubidoux Ground Water Monitoring Program for OU1, the OU2 RA, and the OU4 RD and RA are ongoing at the site. Based on the fourth five-year review data review, site inspection, interviews and technology assessment, it appears the selected remedies are functioning in a manner that is consistent with the decision documents (except as noted regarding the dikes and diversion work portions of the OU1 remedy which are not significantly reducing mine water discharges to Tar Creek). To ensure continued protectiveness, six issues are identified in the following paragraphs.

The first five issues described below are carried over from the third five-year review. Of these, the first four do not currently affect the protectiveness, but they should be addressed to ensure continued protectiveness of the selected remedies. The fifth issue currently affects protectiveness in that current data indicates that potential unacceptable risks to human health and the environment are posed by surface water and sediment at the site. However, a formal evaluation of the data through the risk assessment process is necessary to assess potential human health risks that might exist. The advanced SLERA performed under OU5 has demonstrated that environmental risks are present in site sediments and surface water, but a determination of whether or not the risks are unacceptable has not been made.

The sixth issue currently affects protectiveness in that Appendix H of the OWQS, 785 OAC 45 does not address restrictions on the use of ground water from the Boone aquifer and shallower ground water in areas impacted above remediation goals as called for in the OU4 ROD.

These issues are also summarized in [Table 6](#).

- 1. No O&M Plan exists for the dike and diversion channel for the Admiralty Mine Site (this issue is carried over from the third five-year review).** The ODEQ's O&M Plan for the dike and diversion channel constructed at the Admiralty Mine Site as part of the OU1 remedy was written in 1987 and facts have arisen that make it outdated. The ODEQ is responsible for maintaining the dike and diversion channel at the Admiralty Mine Site, as part of ODEQ's O&M for OU1. The dike at the Admiralty site requires some maintenance to repair damage noted during the site inspection and mowing.
- 2. A determination regarding the effectiveness of the well plugging program, which was intended to prevent mine water infiltration into the Roubidoux aquifer has not been completed (this issue is carried over from the third five-year review).** The Roubidoux Ground Water Monitoring Program has collected data for a period of over 20 years since the RA to plug abandoned Roubidoux wells was completed. In the past, it was believed that the Roubidoux aquifer was being impacted by the mine water; however, only certain indicator parameters were found, and subsequent data collection over twenty years has not found any more reason to believe that the mine water is degrading the Roubidoux. It should be noted that neither EPA nor ODEQ have identified any public drinking water wells at the site that fail to meet the health-based primary drinking water standards (Maximum Contaminant Levels or MCLs) established under the Safe Drinking Water Act (SDWA), and the drinking water supplied from the Roubidoux at the site is safe for all uses. Nonetheless, all available information indicates that the primary mechanism for mine water to enter the Roubidoux aquifer is infiltration through unplugged abandoned wells or infiltration through wells that have faulty well casings and/or poor seals across the Boone Formation; consequently, it is essential that plugging of abandoned wells continue.
- 3. ODEQ research has found references to 19 abandoned wells that need to be assessed for plugging (this issue is carried over from the third five-year review).** The OU1 ROD recognized that additional abandoned wells completed in the Roubidoux aquifer might be identified after completion of the OU1 RA. The ROD stated that the need to plug additional wells would be evaluated as wells were identified. The existence of the wells found by ODEQ's research in historic

documents has not been verified. Field work will be necessary to verify the existence of these wells and to determine whether they are completed in the Roubidoux aquifer.

4. **While significant progress has been made, there is work remaining before the OU2 RA is complete (this issue is carried over from the third five-year review).** Residential yard remediation has been completed in the towns of Picher, Quapaw, North Miami, and Cardin. However, additional work is still necessary to complete the RA for OU2. Chat has been identified in driveways and alleyways in Miami and in other areas of Ottawa County outside of the mining area. The footprints of homes demolished and removed as part of the OU4 voluntary relocation, the footprints of homes demolished in Miami due to flooding issues, and the footprints of homes demolished as part of work performed in Commerce have not been assessed to determine if additional remediation is required.
5. **An assessment of the surface water and sediment data for Tar Creek should be completed to verify that a threat to human health does not exist (this issue is carried over from the third five-year review).** The third five-year review recommended that then current surface water and sediment data for Tar Creek be evaluated to verify that no threat to human health exists in Tar Creek. Since the third five-year review, additional studies have been conducted. These additional studies gathered additional data on the surface water and sediment in site streams, including Tar Creek. The studies also gathered data from fish tissue. Based on this data, the assumptions on which the OU1 ROD fund balancing ARAR's waiver were based are no longer valid. The OU1 ROD stated that fillets of fish caught from the mouth of Tar Creek, the Spring and Neosho Rivers, and Grand Lake were safe to eat. However, recent ODEQ data have demonstrated that potential risk to human health exists through consumption of fish caught from Tar Creek, the Spring and Neosho Rivers, and Grand Lake. The OU1 ROD also stated that the sediments in Tar Creek provide a long-term sink for metals that effectively removes the metals from most biological processes. However, the advanced SLERA documented a moderate to high risk to ecological receptors from sediment and surface water contamination associated with the site. Data from ongoing OU5 investigations of surface water and sediment show that metals concentrations in surface water in site streams continue to exceed the OWQS for its lowered designated beneficial uses.
6. **Institutional Controls (ICs) restricting the use of shallow ground water have not been put in place as called for in the OU4 ROD.** The OU4 ROD calls for ICs restricting the use of the Boone aquifer and also restricting the use of any ground water that is shallower than the Boone. Specifically, the ROD calls for ICs restricting the potable and domestic use of such ground water where concentrations of site-related contaminants exceed the remediation goals established in the ROD. The IC is to be implemented through the OWQS (785 OAC 45 Appendix H). Appendix H of the

OWQS states that toxic metals are present and that special well construction methods are required within the OU4 boundary due to contamination in the Boone aquifer, but there are currently no limitations placed on the use of ground water from the Boone aquifer (or other shallower ground water) for potable use, including domestic supply.

9.0 Recommendations and Follow-up Actions

As described in the previous section, six issues were identified during the fourth five-year review for this site. To address these issues, the following recommendations and follow-up actions have been defined. The recommendations are also summarized in [Table 7](#).

- 1. Develop an O&M Plan for the dike and diversion channel at the Admiralty site.** The ODEQ indicated in the third five-year review that the last O&M Plan developed for the diversion dike and channel at the Admiralty Mine Site was prepared in 1987 and new facts may have made it outdated. The O&M Plan prepared for the Admiralty Mine Site should be updated. Maintenance needs to be performed to the dike at the Admiralty site. The maintenance items identified during the fourth five-year review site inspection should be performed. ODEQ should provide to EPA a schedule that indicates when the O&M Plan will be revised and when the necessary maintenance will be completed. This follow-up action should be completed no later than September 2012.
- 2. Complete the evaluation of the effectiveness of the well plugging program that is intended to prevent mine water infiltration into the Roubidoux aquifer.** It would be beneficial to future long-term decision making if, under the Roubidoux Ground Water Monitoring Program, all the analytical results available from the Roubidoux aquifer were compiled into a single database. The database could then be used to perform statistical and trend analyses on the data to assess long-term changes to the water quality of the Roubidoux. If additional data are required to complete the evaluation, then such data should be collected. Recommendations should then be developed regarding the need for continued monitoring and/or additional actions to protect the Roubidoux aquifer if necessary. The evaluation of the effectiveness of the well plugging program should be completed by September 2014 (prior to the next five-year review).
- 3. Undertake field work to determine whether the 19 wells that ODEQ found in literature actually exist, and evaluate whether plugging any wells found is warranted or feasible.** Each well location the ODEQ found in literature should be investigated, located, assessed, and if necessary and technically feasible, plugged in accordance with the OU1 ROD. As additional potential abandoned well locations are found, field work should be undertaken to locate any wells that exist. If any wells

are found, ODEQ should determine whether the well is completed in the Roubidoux aquifer, and ODEQ should plug those abandoned wells completed in the Roubidoux aquifer where it is found to be technically feasible to do so. EPA will assist ODEQ to plug as many wells as can be located. This follow-up action should be completed by September 2012.

- 4. Remaining actions should be taken to complete the OU2 RA.** These actions include, but may not be limited to: 1) assessment of chat in driveways and alleyways in areas of Ottawa County, including Miami, that are outside of the mining area (approximately 450 in Miami and 50 in other areas of Ottawa County); 2) assessment of the footprints of homes demolished as part of the voluntary relocation (approximately 450 properties); 3) remediation of residential properties located outside of the boundary of the OU4 voluntary buyout, where access was previously denied, and where soil lead concentrations exceed the remediation goal established in the OU2 ROD (approximately 140 properties). Owners of residential properties where access was previously denied will be offered a final opportunity to have their property re-sampled and remediated if necessary. The next five-year review should also consider whether OU2 can be deleted from the National Priorities List (NPL). This deletion of OU2 from the NPL would be a partial deletion of the site. This follow-up action should be completed by September 2015.
- 5. The EPA should complete the evaluation of current surface water and sediment data for Tar Creek to verify that no unacceptable risks to human health and the environment exist in Tar Creek.** Numerous studies have been conducted since the third five-year review. These studies have collected surface water and sediment data in Tar Creek and other site streams. If necessary, the EPA should collect enough additional data to determine whether potential risks are posed to human health and the environment by the surface water and sediments in streams of the Tar Creek site. The risks should be quantified through a risk assessment. If unacceptable risks are identified, then potential remedial alternatives will be evaluated to address the identified risks. Potential remedial alternatives may include engineered remedies, such as passive treatment through constructed wetlands. A determination may also be made that it is still technically impractical to address surface water and sediment through an engineered remedy and/or that no further action is required. The risk assessment portion of this follow-up action should be completed by September 2012. If necessary, an evaluation of remedial alternatives should be completed by September 2014 (prior to the next five-year review).
- 6. The IC restricting potable and domestic use of shallow ground water including the Boone aquifer as specified in the OU4 ROD should be implemented.** The OU4 ROD calls for ICs restricting the use of the Boone aquifer and also restricting the use of any ground water that is shallower than the Boone. Specifically, the ROD calls for ICs restricting the potable and domestic use

of such ground water where concentrations of site-related contaminants exceed the remediation goals established in the ROD. The IC is to be implemented through the OWQS (785 OAC 45 Appendix H). Appendix H of the OWQS states that toxic metals are present and that special well construction methods are required within the OU4 boundary due to contamination in the Boone aquifer, but there are currently no limitations placed on the use of ground water from the Boone aquifer (or other shallower ground water) for potable use, including domestic supply. The ODEQ has indicated that it will explore placing a restriction in Appendix H of the OWQS limiting ground water use from the mine pool and the Boone aquifer in the immediate vicinity of the mine pool for public water supply, or domestic use. The ODEQ's restriction will include treatment requirements to remove any lead above the MCL of 15 micrograms per liter. EPA suggests that the State of Oklahoma review this IC. This follow-up action should be completed by September 2011.

10.0 Protectiveness Statement

The remedies implemented for the Tar Creek Superfund Site are protective of human health and the environment, except as noted in this five-year review regarding the need for further assessment of potential surface water and sediment impacts on human health and the environment.

The OU1 remedy addressed the primary route of potential human exposure by protecting the Roubidoux aquifer, and, in this way, preventing the possibility that hazardous substances would be ingested in drinking water. Sampling data indicate that the Roubidoux aquifer continues to meet all health-based primary drinking water standards at currently operating municipal wells.

Some of the exposure assumptions and the potential risks posed to human health and the environment for surface water and sediments at the site that were stated in the OU1 ROD are no longer valid. Recent fish tissue data collected by ODEQ demonstrate that potential risks to human health exist through consumption of fish caught from Tar Creek, the Spring and Neosho Rivers, and Grand Lake. Metals contained within site sediments are biologically available and pose risks to ecological receptors. The concentrations of site-related contaminants in Tar Creek surface water continue to exceed the OWQS. The narrative and numerical criteria in the OWQS are designed to maintain and protect the beneficial surface water use classification of "Fish and Wildlife Propagation". Under the OWQS there are numerical "Toxic Substance" concentration limits for surface water with both "acute" and "chronic" standards listed. Under 785 OAC 45 OWQS, "acute toxicity" means the surface water concentration of a toxic substance is such that it means greater than or equal to 50% lethality to appropriate test organisms in a test sample. Under those same standards, "chronic toxicity" means the surface water concentration of a toxic substance is such that there is a statistically significant difference (at the 95% confidence level)

between longer-term survival and/or reproduction or growth of the appropriate test organisms in a test sample and a control. Teratogenicity and mutagenicity are considered to be effects of chronic toxicity. In Tar Creek, Lytle Creek, and Elm Creek at the Tar Creek Site, EPA found that cadmium, lead, and zinc concentrations in surface water samples exceed the OWQS chronic toxicity standard, and zinc concentrations also exceed the acute toxicity standard. Finally, initial construction costs for the constructed passive wetland southeast of Commerce are considered reasonable and may be an economically feasible engineered remedy for contaminated surface water at the site. Long-term O&M costs for such a passive wetlands system still require further evaluation. For these reasons, the fund balancing ARARs waiver contained in the OU1 ROD may no longer be appropriate, and should be reevaluated.

The remedy being implemented for OU2 is protective of human health and the environment in all areas where remediation has been completed. A total of over 2,295 properties have been remediated during the OU2 RA and during the removal actions that preceded the RA. Remaining items needed to complete the remedy are being evaluated. The RA for OU2 is ongoing and is scheduled to be completed by the next five-year review. Human health and the environment are being protected by the remedy for OU2.

The action implemented during the Removal Action for OU3 is protective of human health and the environment. The laboratory chemicals left at the former Eagle-Picher Office Complex were removed from the site and properly disposed of.

The RD and RA for OU4 are currently being conducted. The voluntary relocation is in progress and anticipated to be completed in 2010, and chat sales continue at the site. Under OU4, Appendix H of the OWQS 785 OAC 45 does not limit use of the ground water from the Boone aquifer as called for in the OU4 ROD. The OU4 Remedial Investigation (RI) identified 13 private wells completed in the Boone aquifer at the site that were being used as a source of drinking water. Of the 13 wells, testing showed that concentrations of site-related contaminants exceeded remediation goals in only two of the on-site private wells. The OU4 ROD includes provisions for these two residences to be provided with an alternate drinking water supply as part of the OU4 RA. Action to address the IC in the OU4 ROD with respect to restricting potable and domestic use of shallow ground water and ground water from the Boone aquifer still need to be taken. The OU4 remedy will be protective of human health and the environment once completed.

Investigations are currently being conducted for OU5.

With the exceptions noted above for OU1, the completed RAs, Roubidoux Ground Water Monitoring Program, and O&M activities for the Tar Creek Superfund Site are all protective for the short term due to the implementation of the 2008 fish consumption advisory for OU1 and because the population most at risk has been relocated under OU4. The remedies will continue to be protective in the long-term if the action items identified in this five-year review are addressed and the remedies are implemented as selected in the RODs.

11.0 Next Review

The next five-year review, the fifth for the site, should be completed during or before September 2015.

Attachment 1
Documents Reviewed

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Attachment 2
Interview Record Forms

Attachment 2 will be included when the interviews are completed.

Attachment 3
Site Inspection Checklist

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Attachment 4
Site Inspection Photographs

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Attachment 5
Notices to the Public Regarding the Five-Year Review

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